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# SCHOOL SCIENCE AND MATHEMATICS

**A Journal for Science and Mathematics Teachers in Secondary Schools**

*Founded by C. E. Linebarger*

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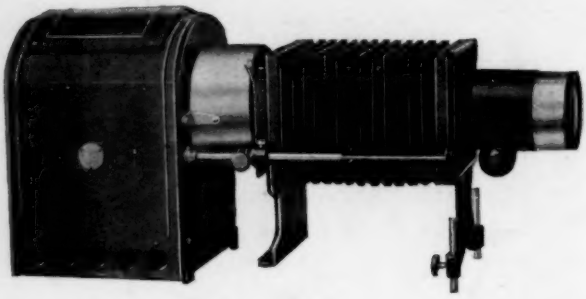

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# SCHOOL SCIENCE AND MATHEMATICS

VOL. XVI, No. 6 JUNE, 1916 WHOLE No. 134


## METHODS OF INCREASING THE EFFICIENCY OF PUPIL AND TEACHER IN SECONDARY-SCHOOL CHEMISTRY.


BY WILHELM SEGERBLOM,

*The Phillips Exeter Academy, Exeter, N. H.*


The thought of the teacher and the thought of the pupil, with the consequent progress made by each, are so closely interwoven in a subject pursued with such close personal relationship as obtains in a laboratory course, that the progresses made by the teacher and by the taught may be lumped into one common advance, and the efficiency of the combined efforts may be considered from the two points of view of the science itself and of the directorial management of the laboratory, the former being further subdivided into the presentation of the theory of the science and the handling of the laboratory work. Let us look at these three phases of the chemistry teacher's problem.

If chemists knew the one principle underlying *all* chemical action under *all* conditions they might safely start with that principle and deduce therefrom the knowledge obtainable at the laboratory desk. In that case chemistry would become a deductive science and much of our present educational paraphernalia, laboratories included, would be worthless. But, as we well know, not being yet blessed with omniscience, we collect our facts, arrange and study them, and formulate statements which we designate "general principles." Then we are tempted to congratulate ourselves upon the splendid results of our inductive endeavors. Are we consistent if we collect our "general principles" into one chapter and present that to our students at the beginning of the school year? Are we fair to the students if we do not let them gain a sufficient stock of facts and a sufficient acquaintance with the chemical substances and their reactions before we present certain general principles of which we ourselves have gained

an intelligent conception only after considerable laboratory work? Are the pupils not in danger of accepting the "general principles" (which we know hold absolutely only for cases actually studied) as the one general principle underlying all chemical action? For most students individual work at the desk in the chemical laboratory is in itself such a novel experience and so full of surprises that we may well wait till they have become accustomed to the new experiences. When the ordinary student mind feels the need of theory to help set in order his rapidly accumulating facts, then he will reach out naturally for it and will assimilate it with less effort. With this point of view constantly guiding us, it should be an easy task to lay out a consistent and logical first-year course in chemistry.

To my mind such a course should begin with solids instead of gases, for it is natural that the beginner should be able to get more tangible results from the more tangible substances. Such metals as copper, zinc and magnesium and such nonmetallic solids as sulphur and phosphorus lend themselves admirably to this plan. The ease with which these substances oxidize leads directly to oxidation, oxides as a class, and the formation and composition of certain acids therefrom; with the next logical topic, the action of acids on metals, we are fairly under way in our experimental study of chemical action. Work on gases should be introduced only as soon as the students have learned to handle the solids intelligently from the chemical point of view. In all this work it is of the utmost importance that we do not turn the students loose in the laboratory and expect them to invent their own methods of working. It is as essential to teach them *how to work* as it is simply *to work*. If secondary-school teachers of chemistry would persistently teach a *few* things well, and not try to touch the whole field of chemical science, perhaps their friends —the college professors of chemistry—might gladly accept the fruits of these labors and might find a more solid foundation upon which to build the chemical superstructure.

If at present the burden falls unduly heavily upon the secondary-school teachers of chemistry, this should in no wise discourage them, for it simply increases their opportunity of achieving much-wished-for results. One of the objects to be constantly striven for is to turn out students who are not chemical investigators but who are able to think their own way out of difficulties of reasonable severity. To attain this, the instructor should have, and should constantly hold to, a proper sense of proportion of the var-

ious topics that he takes up with his class. It is well to remember that students in the laboratory often learn as much from what the instructor does not say as from what he does say. It behooves him, therefore, to maintain always a scientific attitude of mind and to reflect those traits of mind, such as unprejudiced honesty of observation, subsequent logical thinking, and willingness to repeat correctly the work done wrongly the first time, that he expects his students to manifest, and the most effective time to do this is when he is working out the unexpected problem at the student's elbow.

Suppose, for instance, that an experiment does not come out right for a student, and the teacher performs the experiment with the student to show him how it should be done. Suppose, in filtering a mixture to get a clear filtrate that the filtrate comes through slightly muddy. Should the teacher be satisfied with "Well, that *ought* to come through clear, but, never mind, we'll use it as it is?" Will that student filter correctly the next time? Won't he rather eye the teacher askance, and quote to himself: "Huh, don't do as I do, but do as I tell you." Such an attitude of mind does not breed cooperation between minds which should be kindred.

Originality of thought on the student's part should of course be encouraged. How much more of real value was contained in the conclusion that a certain student reached through his own thinking that vacuum was "drawn out space" than was the labor of another student who spent nearly an hour carefully preparing a flask for determining the specific gravity of carbon dioxide, and then, when he was ready to replace the air in the flask with carbon dioxide, did not remove the stopper from the flask, with the result that the pressure from the gas bag shot the flash across the desk and smashed it against the locker across the next aisle.

Not only should honest and thoughtful work be insisted upon and preached by example, but slovenly English and careless and inaccurate expression of ideas should not be accepted. Witness some examples taken from examination papers handed in by some of my own scholars at such times as I have not insisted upon thorough work. A boy whom the text had taught that some chemicals taste sour, some salty, others bitter, others metallic, etc., was asked to name the different kinds of taste that he had recognized in the laboratory. He said, "Good taste, bad taste, medium good taste, and medium bad taste." Another boy, asked to define "filtrate," stated that it "is a substance obtained in the

*reciprocal* beneath the filter." Still another student, asked to state the law of Definite Proportion by Weight, instead of explaining that every distinct chemical compound has a fixed and unalterable composition, said that, "If a variable is added to a fixed compound the composition is unchangeable." This was neither mathematics nor chemistry, but, like Tegner's description of the midnight sun, "'Twas neither night nor was it day, but wavered between the two." At another time the question read: "Give the reason for cooling the crucible containing the heated copper before weighing it in the horn-pan balance." In trying to say that the hot crucible would heat the air around it, thus causing an up current of air that carries the pan up, making the weight appear lighter than its true weight, one student muddled things thus: "One reason is the upper currents of the air would be affected by the heat coming up from the heated crucible and thus the weight would be greatly affected." And again, the various kinds of solutions, dilute, concentrated, saturated, and supersaturated, were described as follows:

A dilute solution is one which is weakened.

A concentrated solution is one which is overdosed.

A saturated solution is one which is just right.

A supersaturated solution is one which is too much saturated.

Some germs of budding knowledge there—for whosoever is able to find them. What conception must such minds have of the beauties and wonders of natural science?

Compare the foregoing with the following lucid answer (taken from another examination paper) to the question, "In getting the combining number of magnesium why must the correction for aqueous vapor be subtracted from the reading of the barometer?" "Since the level of the water inside the bottle and out is the same, it shows that the pressure inside and out is the same. But we know that the pressure inside is due not only to the hydrogen but also to the water vapor. Therefore, since we want to know the pressure of the hydrogen alone it is necessary to subtract the correction for the water vapor from the air pressure. This is made clear by an equation:

"Pressure inside the bottle = pressure outside the bottle;
∴Air pressure = pressure of the hydrogen+pressure of vapor;
∴Pressure of hydrogen = air pressure—pressure of vapor."

We occasionally find statements in chemistry textbooks that are less satisfactory than the above answer.

Chemical problems should test a knowledge of chemistry rather

than arithmetical ability; for that reason the figures might well be selected so as to reduce the actual mathematical calculation to a minimum. I find in my own work that it often helps the student if I indicate how many decimal places should be saved throughout the work if decimals appear.

So much has been said on the subject of equation writing that I hardly dare to add another word, but I do wish to emphasize the necessity of using equations only as a mode of expressing weightier facts instead of as things by themselves. It follows, then, that equations written by the students should so far as possible be based on experiments actually performed.

My own classes do not use the ordinary chemical symbols and formulæ in equations until they have had some of the theory by which they have been obtained. Instead they write equations during the first few months with little or no regard to quantitative relations and only with reference to qualitative composition. This they do by writing the name of each simple substance that figures as such in the reaction out in full and putting brackets around it; each compound substance is similarly represented by writing the names of the elements which they find by actual experiment it contains one over the other and enclosing the list in brackets. This method takes a little longer, but it has the advantage of following more closely the student's actual experience in the laboratory.

My own experience has convinced me that the formal lecture in chemistry has little place in a first-year course. It may be used to advantage with the second-year class, but the first year should not be wasted in lectures when there is such a splendid opportunity for pupils to gain first-hand knowledge personally at the laboratory desk.

Valuable as is the recitation or the quiz, I find that the casual question while the student is busy with his experiments is often more fruitful in productive thinking.

My own experience shows that qualitative analysis* (meaning thereby a systematic examination of unknown mixtures) has no place in a first-year course. This of course does not exclude the recognition of common chemicals by their prominent properties with wet test for the three common mineral acids and for a limited number of the commoner metals.

Another point: A teacher might as well commit professional suicide as to try to bluff a student who asks a question that he cannot answer, for students are usually brighter than their teach-

ers. Better dare to say "I don't know" and merit the respect of the pupil. Then, if possible, try some experiment in the laboratory with the student in the endeavor to settle the point in question.

Concerning the directorial organization of the teacher's work it should not be necessary to speak in detail in these days of highly organized business management, but since secondary-school teachers presumably have not had much experience in business management, it might be to their advantage to subscribe for, and read, some good periodical on business methods. Many of the labor-saving devices improvised by successful business men may be adapted to the needs of the secondary-school teacher. A judicious use of the card system suggests itself first. As another instance, ordering apparatus by multiples of ten instead of by the dozen enormously economizes the bookkeeping and stock-room work.

Speaking of card systems, it occurs to me that it is well to have all record cards of the same size, say 3 x 5 inches, which is a standard market size. Expenses may be kept down by buying, not elaborate quartered-oak cabinets, but substantial, pasteboard transfer cases which many filing dealers sell, and have the local printer cut up cheaper paper or cardboard stock for records which are for temporary use only. If the cards are to contain columns, let them appear from left to right in the order that they occur in the user's mind at the time of use, not in columns that are to be filled in at the left of the reading-matter column, as I have seen in some cases. One very helpful use for such cards is for students to hand in results of quantitative experiments on them. By having the student fill in the results that he gets at the various stages during the experiment the teacher can tell at a glance whether the student has got wrong numerical data or simply made arithmetical errors after getting correct data. Thus he can immediately locate the error and save time and effort for both himself and the student.

It goes without saying that things in the laboratory should be handily arranged so as to save steps, time and strength. The principle that prompts the manufacturer to arrange his machines in rows in the order in which the different stages of his work follow each other, thus enabling his men to do the largest amount of work in the least amount of time, with least amount of effort and with greatest profit, might well govern the arrangement and running of laboratory work.

Speaking of expense, it might be well to remember that some

of the dealers in chemical apparatus are ready to cooperate with users by importing, duty free, even small quantities of apparatus, thus effecting a considerable saving to the school.

A systematically arranged collection of substances that are of interest to students of chemistry is of great help.

For convenience the collection may be divided into three parts: (1) the elements, (2) the compounds, and (3) specimens to illustrate the chemical arts and manufactures. The first two divisions are mainly of theoretical interest because the elements and compounds should be arranged according to their scientific classification. Much, however, of practical value and of technical interest is interwoven, if the substances stand side by side on the shelves, as they are made in the laboratory, as they occur in nature, and as they are used in technical processes. The third division of the collection is of practical interest primarily, showing how the substances classified in the other two divisions are used in the various industries. This division naturally covers a very wide field. Several firms are ready to donate specimens to illustrate the manufacture of their special lines of goods. These samples often include specimens of the raw material, specimens of material during the different stages in the process of manufacture, side products, residues, and finished products.

I cannot understand the mental attitude that says that chemistry should be "made attractive" to the students. Chemistry is, in and of itself, so intensely attractive that it seems to me our only danger is in making it unattractive by dressing it up in inconsistent, illogical, and unscientific methods of presentation.

The secondary-school teacher of chemistry has one advantage over his fellow laborer—the college teacher—in that he has better opportunity for research of an extremely profitable kind.

The investigation of compounds and processes he may well leave to the college man with his larger equipment and command of research assistants. The secondary-school teacher can research in fields that are closed to the college man; that is, he can investigate, devise, try, improve, and finally settle the best methods of producing satisfactory studential products from first-year classes in his subject. Surely the time is ripe for more productive elementary chemistry teachers.

Finally, the teacher of chemistry should both aspire and inspire —aspire, himself, to reach perfection in his calling, and inspire his students to ever higher effort. If he does the first, the second will take care of itself.

## AN ELEMENTARY OPTICAL BENCH.

By H. W. Farwell,
*Columbia University, New York City.*

I have been asked to give some details with respect to the optical bench which has been in use in our elementary laboratory for four or five years. This apparatus is both simple and efficient, and has proved its value during a period of years in which it has been given severe tests of all kinds. The usual outcome is to find that its usefulness grows with lapse of time, rather than decreases.

For the benefit of those who are unfamiliar with the situation, it may be well to state that for a number of years we had been using in our elementary laboratory precisely the same equipment which is to be found in high schools all over the country. It served its purpose after a fashion, and enabled some of the students at least to realize in the laboratory what they had been led to expect in their lectures. However, the signs of senile decay appeared in a comparatively short time, and in truth were hailed with delight by students and instructors.

To accomplish the teaching results, it was necessary to obtain something better, and something better meant a large outlay of money. We compromised by building our own apparatus, making use of the ideas and experience gained through years of unsatisfactory experimenting with inadequate apparatus. The results can be best shown by diagrams.

The bench is built upon a meter stick, as before (though we are now using with much success a double meter stick). This meter stick is supported by two heavy cast iron legs, high enough to allow the hand to be placed underneath for convenience in various adjustments. To the bar are attached simple clamps which are to carry either holders for mirrors, lenses, or screens, or small rods for pins. The holder was designed in such way as to serve equally well for the various objects required; in other words, the number of different pieces was reduced to a minimum.

One important point is the size of the mirrors and lenses used. Personally, I consider the success of the bench due fully as much to the insistence of my colleague, Dr. Stifler, that the mirrors and lenses be of sufficient size to enable the student to see what he was looking for as to any mechanical part of the outfit. As long as the field of a concave mirror, for example, is extremely small, the student will waste much time in trying to see the image, let alone locating it.

Another important item is the possibility of making adjustments to bring the images into positions desired. The lenses should be readily rotated, about a vertical axis, elevated, or moved sideways. The screens, etc., should have similar adjustments. These and many other considerations led to the adoption of the design given.

Before giving a few illustrations, it might be well to add that practical use in the parallax method of locating images is much facilitated by having the screen-holder and clamp separate. Then the student can readily check by using a pin and the parallax method the position of an image which he has just caught on a screen. It is true that some teachers care nothing for the parallax method, considering it too tedious or too difficult. It is, nevertheless, an important method, and practically the only method available to elementary students for locating virtual images.

It is interesting to use the parallax method first in connection with a plane mirror. This is done on the optical bench by setting the mirror near the middle of the bar, then rotating its holder until looking along the bar the image of the bar appears as a continuation of the bar itself. This adjustment is necessary but frequently cannot be made on account of the limitations of the apparatus. A short pin is set at some suitable point in front of the mirror to serve as object. A tall pin (hatpin) is then set behind the mirror at such a point that, as the observer moves from side to side, the top of the tall pin always appears to be a prolongation of the image of the shorter pin. The tall pin then marks the position of the image of the other. We prefer to use pins with heads of two different colors to avoid confusion in the minds of the students. Evidently, the location of the virtual images in case of convex or concave mirrors is quite similar.

Perhaps the experiment with the conjugate foci of a concave mirror will illustrate as well as any the advantages of proper apparatus. Here the mirror is mounted near one end of the bar, and a ground glass screen with scale ruled upon it and held in one side of the holder is set upon the bar at some distance from the mirror. This screen is illuminated from behind by a lamp. Another similar screen is set in the other side of a second holder and adjusted to receive upon it the image of the scale. This setting can be easily made, and if the lamp be placed behind the second screen, its image will be found on the first screen. By

using screens with millimeter scales ruled upon them, the relative magnification is quickly determined.

If the parallax method is desired, it may be used as a check, merely by removing the screen-holders from the clamps, and replacing them by the pin-holders. It may be necessary to rotate the mirror slightly about the vertical axis, but this adjustment is quickly made.

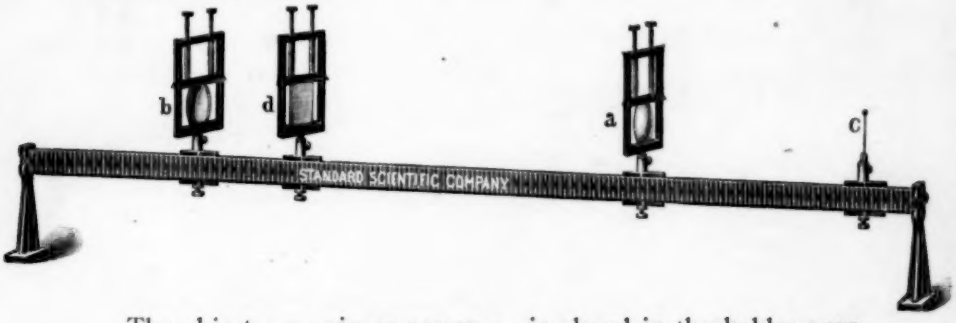
There is nothing new in these experiments, but many of this type have not been available. With better apparatus, there is much more encouragement to be observant. Only a few days ago, a student working in the center of a room where there were windows on both sides made a discovery which pleased him very much. He was finding the focal length of a convex lens, and used for the purpose an opaque screen with an opening in the center as object. The light from this opening passed through the lens to a plane mirror which sent the light back along the path by which it had come. When this young man had set the screen so that the image of the opening was clearly formed on the screen beside the opening itself, he noticed also, on the screen, two distinct images of buildings. On experimenting to discover the source of the light, he found that one image was that of those buildings outside the room behind the mirror, sufficient light passing around the mirror to give the image. The other image was that of the buildings on the other side of the laboratory, the light having first been reflected from the plane mirror. This was not a matter of importance as far as methods go, but for the young man it was very important. He gained more that day from his work than in several days of work by rote.

It might be mentioned that the whole equipment is so light and yet sufficiently rigid and secure that it may easily be carried near a window in order to find in the sunlight the focal length of a lens by setting a screen at the burning point. The problem of determining experimentally the focal length of a concave lens, often left to the imagination of the student, becomes with such equipment as simple as for a converging lens.

Such simple combinations of lenses as models of the astronomical and terrestrial telescopes and compound microscope are of great interest to the average student of elementary optics. The objection to setting up such models with most benches lies in the difficulty of accurately *centering* the lenses. This is particularly true in case the exigencies of laboratory equipment re-

quire the use of lenses of different diameters. Here again this bench meets the practical need, for the clamp and "universal" holder give *vertical adjustment* of ample range.

As an illustration of the formation of images in a compound optical instrument, the setting up of a microscope will be described. It is supposed that the student has completed the exercises with simple lenses, and is thus familiar with the image process in general.




The object *c* — pin or screen — is placed in the holder near one end of the bar. By means of the object-glass *a*, an enlarged inverted real image is formed on ground glass screen *d*. The lens *b*, corresponding to the eyepiece, is then set in such position as to form a virtual image (enlarged) of the granular surface on the screen. Thus far, the student has merely repeated two of his earlier exercises. If now he removes the screen *d*, he finds on looking through the system that his microscope is complete.

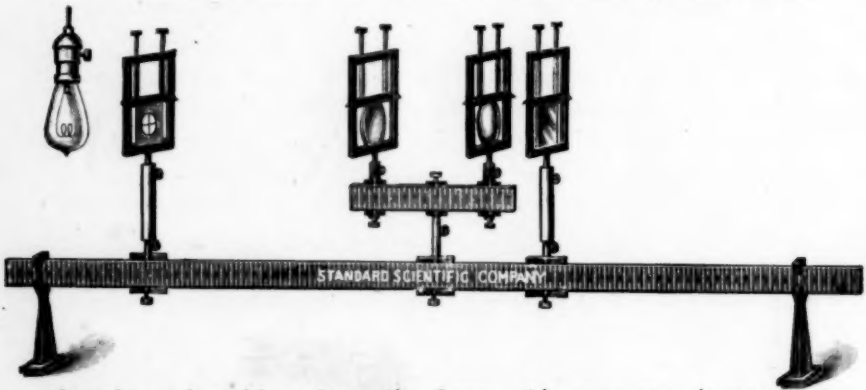
The determination of one wave length of light by diffraction grating, if attempted at all in elementary courses, usually requires a spectrometer or a rather clumsy arrangement of more or less special appliances. With this bench, on the other hand, the determination of the wave length of, say, sodium light, requires only the addition of a half-meter stick with a central transverse slit. Any grating and light source suitable for such an experiment may be used. A reference to the cut will make plain the actual arrangement of the apparatus. The half-meter stick is supported at right angles to the bench by means of two of the sliding clamps, held together by a pin-holder. The principle of the method consists in measuring on the half-meter stick the distances ($p$) from the slit to the various orders of spectrum image, whence, knowing also the distance ($d$) of the slit from the grating and the value ($a$) of the grating space, we can determine the wave length ($\lambda$) by the following formula:

$$\frac{n\lambda}{a} = \frac{p}{\sqrt{d^2+p^2}}$$

wherein $n$ is the "order" of the spectrum image. The images can be conveniently located by using paper slides on the half-meter stick. The theory of the method can be found in any standard textbook of physics.

The bench has been found to be capable of giving most satisfactory results in many special uses. As an example of this, I may cite its use in the determination of the equivalent focal length and the positions of the nodal points of a combination of two or more lenses separated by several centimeters; thus illustrating one of the common problems in testing lens-systems. The theory of this method may be found in such books as Clay's *Treatise on Practical Light*.

The diagram shows the special apparatus which takes the place of the elaborate "Nodal Slide" described by Clay. Al-




though, as is evident from the figure, this apparatus is not intended for commercial testing of such systems as photographic lenses, for emphasizing the principles involved in such tests the arrangement has evident advantages.

I might state that the bench has been used satisfactorily in some very interesting experiments with cylindrical lenses. The ease of changing various parts has been a great help in these experiments.

Not everyone would care for extended applications, but many would like to know that their apparatus could be further used if necessary. An optical bench of this sort is not a panacea for all the ills of physical science, it will only serve its turn with the rest in a very small part of the subject, but anything which will add alike to the joys of learning and of teaching deserves at least a word or two in passing.

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## INVAR AND RELATED NICKEL STEELS.

The Bureau of Standards, Department of Commerce, proposes to issue a series of circulars of information on the properties of the more interesting or technically important metals and alloys. The first of the series, describing the properties of the non-expansible alloy invar and other nickel steels, has just been published. The magnetic, electrical, thermal, and mechanical properties are given with numerous illustrations, together with statements concerning microstructure, constitution, applications, and sources of supply.

The publication is Circular No. 58, entitled *Invar and Related Nickel Steels,* and copies will be sent free to interested persons upon application to the Bureau of Standards, Washington, D. C.

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## READERS' GUIDE SUPPLEMENT.

All readers of this Journal undoubtedly desire to be and are endeavoring in every way possible to make themselves as highly efficient in their line of work as they can. When one is making a study of any particular subject, they desire to know where all articles or papers bearing upon the question can be secured. There is no better way to be put in touch with information like this than through the Readers' Guide Supplement, published by the H. W. Wilson Co., White Plains, N. Y. Teachers who are endeavoring to keep a card index of articles in which they are interested will find it to their interest to secure a Readers' Guide and under the proper heading they will find the papers listed which they are seeking. These may be easily cut from the Guide and pasted on the cards of one's files, thus saving time and making a card index which is worth while.

## THE FUNDAMENTAL CONCEPTS OF ELECTRICAL ENERGY AND THE BEGINNING STUDENT.

By O. L. Brauer,
*Selma, California.*

The average student beginning the study of electricity in the high school soon finds himself in about the following state of mind: Volts, amperes, and coulombs all seem to represent the energy of the current in some hazy sort of a way. For instance, a circuit contains a battery and a motor; the cell furnishes energy and it takes energy to run the motor, yet the current is the same after leaving the motor as it was on entering. This appears to be an impossibility. Energy must have been used up in making the motor go, yet the current, which appears to represent the electrical energy, is not diminished. The usual textbooks do not make the factors of electrical energy clear. The term, ampere, is a new concept to the student. In dealing with heat energy there is no single word expressing rate of flow. In using the water analogy, there is no common term expressing gallons per second or rate of flow. (Very few are familiar with the miner's inch.) It is extremely unfortunate that the term, ampere, should ever have been used in a high school text. The words, coulombs per second, would convey much more meaning and less confusion to the student. It is still more unfortunate that an ampere should ever be defined in any other way than as a coulomb per second, because any other way of defining it leaves the student in darkness as to the real meaning of an ampere; namely, the rate of flow. The coulomb should then be defined as that quantity of electricity that would electrolytically deposit .001118 gm. of silver.

Another point often left indefinite is the harmonization of the law of induced currents with the law of conservation of energy. A student is told that for a given current in the primary circuit, the more turns in the secondary circuit, the greater the induced E. M. F. This appears to him to be a method of creating energy by simply adding more turns to the secondary coil. I have seen juniors in college who had not cleared up this point. They knew that the law of conservation of energy must hold, but could not see how.

To clear up the former relations, and to emphasize their significance, I have found the following tables very useful.

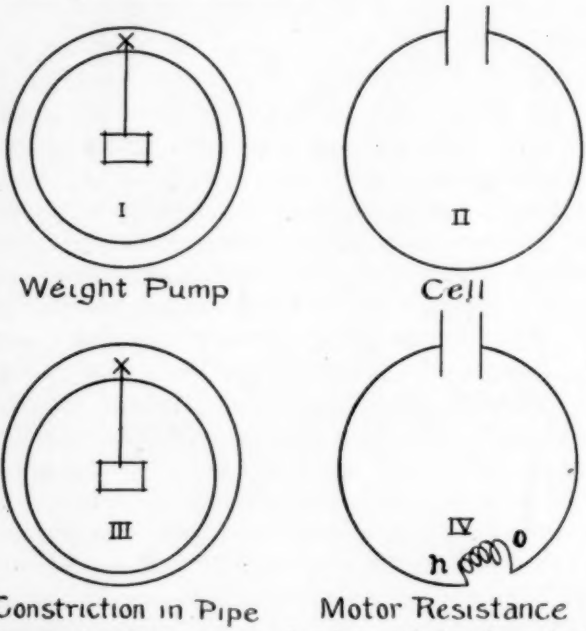
| | Water (Analogy). | Heat. | Electricity. |
|---|---|---|---|
| Measure of quantity. | Gallon. | Calorie. | Coulomb. |
| Rate of flow. | Gallons per second. | Calories per second. | Coulombs per second (amperes). |
| Cause of flow. | Difference in pressure lbs. per sq. in. | Difference in temperature, degrees. | Difference in potential, volts. |
| Resistence to flow. | Smaller pipe. | Poor conductor. | Electrical resistance (ohms). |
| Rate of doing work. (Energy expended per second.) | Lbs. water moved per second times difference in pressure. | Work is related to but not exactly equal to calories moved × the difference in temperature. | Coulombs per second × difference in potential, or volts times amperes. |
| Total work. | Lbs. water × difference in pressure × time. | | Volts × amperes × seconds, watt-seconds. |

From this it can be pointed out that the gallon, calorie, and coulomb are convenient units of quantity. The first two are already familiar and the last can be readily conceived by the analogy. Then, rates of flow can be compared with one another and the fact "driven home" that the word, amperes, is simply a shorthand expression for the coulombs per second. The student should be encouraged to substitute coulombs per second for amperes all through the text.

Now, taking up the cause of the flow, it can be pointed out that the cause is similar in each case. A small stream of water can be driven from a tank of water under great pressure to one under small pressure through a very small pipe and not represent as much energy or ability to do work, as a large stream under a lesser difference of pressure. A small amount of heat transferred through a small wire from a body 200°C. to another 0°C. might not be able to melt as much ice as the heat carried through a large bar of silver from a body at 100°C. to the same body. The electricity driven through a small wire of great resistance cannot make as strong an electro-magnet as that driven through a large wire of small resistance between the same difference in potential in each case. Thus neither the current nor the difference in potential alone represents the ability of the current to do work, as does neither the rate of flow of water nor the difference of pressure alone represent the work that the water could perform. For example, 10 lbs. of water driven under 5 lbs. difference in pressure, 5 lbs. of water under 10 lbs. difference in pressure or 25 lbs. water under 2 lbs. pressure are all capable of doing the same work. Likewise 10 amperes moving under 5 volts difference in potential can do the same work as 5 amperes under 10 volts and 25 amperes under 2 volts.

To show why the current is the same in all parts of the circuit

the water analogy is again convenient. Think of water in a pipe in a closed circuit, with a weight pump in one part. This is analogous to an electric cell short-circuited through a wire. As long as the pipe is full of water, more gallons cannot pass any point in one part of the circuit than in others. The electricity is confined to the wire and likewise more coulombs cannot pass a point in one part than in another.




(Think of the above water circuits as being in a horizontal plane so as to eliminate variation in gravity effects as far as possible.)

If resistance is put into the water circuit by making part of the pipe smaller, the current of water will be less; that is, fewer gallons will pass any point in the circuit per minute, but just the same number will pass a point before the constriction as after it. Likewise, if a motor is put into the electrical circuit fewer coulombs than in the previous circuit will pass a given point per minute but just as many will pass a point before the motor as after it. The electricity may be thought of as already filling the wire as the water fills the tube, but it does not show itself until a pump starts it moving, which pump is the cell. In the case of both the water and the electricity, for a given driving force, the water or the electricity must pass in equal quantities in all parts of the circuit.

The driving force, however, spends itself as the current is driven through more resistance in the circuit. At a point in the external circuit, the driving force is represented by the difference in potential between that point and the negative pole. This driving force gets less and less but the current is the same. Energy or ability to do work is used up in running the motor, as is shown by the decrease in the product, current times voltage, which is the difference in potential between the given point and the negative pole of the cell.

In circuit No. 4, any point as *n* represents a certain amount of work already done and the ability to do some more work. We have just seen that energy must be represented by the product of two factors, the current and the voltage, or difference, in potential. The work already done by the current in going from *m* to *n* is the difference in potential between *m* and *n*, multiplied by the current. The work that it can still do is represented by the difference in potential between *n* and *p*, multiplied by the current. This, as was shown before, represents the energy of the current at this point. The energy of the current at *o*, after it has gone through the motor, is E*o*—*p*×C where E*o*—*p* is difference in potential between *o* and *p* and C is the current. The energy used up by the motor is (E*n*—*p*×C)—(E*o*—*p*×C).

To clear up the point concerning induced currents, it is now only necessary to recall the fact that the energy of the current is only represented by the product of the voltage and the current.

In the primary circuit there is a large current and small difference of potential while in the secondary circuit there is a correspondingly larger voltage and smaller current, for the product, volts times ampers, must be the same for the two circuits if we neglect loss in the process. In reality there need not be over three per cent of energy lost. Ohm's Law must hold for the secondary circuit as well as the primary. Although each additional turn increases the voltage that is induced, it also adds that much to the resistance of the circuit.

It is hoped that these suggestions will aid some young teacher in presenting the fundamental concepts of electricity more clearly.

## A METHOD OF PRESENTING LABORATORY EXERCISES IN PHYSICS.

By John R. P. French,
*Pawling School, Pawling, N. Y.*

*"The child ought to have a positive consciousness of what he is about, so as to judge his acts from the standpoint of reference to the work which he has to do."*—John Dewey.

I do not know whether what I am about to describe has been done, or is being done. It is for me a quite recent discovery; and I find it useful. It seems to me also to possess certain demonstrable theoretical advantages.

During ten years of secondary school teaching, I have tried various methods of conducting class laboratory exercises in physics. I have dictated full directions to the class immediately before they went to work; I have assigned directions as lessons to be studied outside; I have distributed printed direction sheets to each member of the class; and of late I have come back to the method of dictating directions, but with a difference.

Let us suppose the class is to perform in order the following:

1. Measurement of the sides of a right triangle.
2. Density of a block of wood by measurement (spring balance).
3. The straight lever, first class.
4. Second and third class levers.
5. Center of gravity and weight of a lever.

For numbers 1, 2, and 3, directions are given in full, including specific directions for working out results. Number 3 has been preceded by a discussion of the practical uses of levers (class furnishing examples) and the point has been developed that levers may be classified as (1) fulcrum-in-the-middle, (2) weight-in-the-middle, and (3) power-in-the-middle.

Following number 3, the class is told this: "You will be expected tomorrow to devise for yourself experiments to demonstrate whether the law of levers that you worked out in number 3 holds good also for levers of the second and third classes. You may use only such apparatus as you are already familiar with." It will be noted that in number 3 no spring balance is used; while number 4 requires the use of the spring balance. This the pupil is left to discover for himself. On commencing the exercise, the class is told to record results in such a way that both method and conclusion will be evident. I may add here

that it is my custom during laboratory exercises to remain seated at the end of the room. Difficulties may be brought to me there; and finished records are brought for correction or checking. I find it only occasionally desirable to accompany a pupil to his working station.

Preceding number 5, a discussion of the concept "center of gravity" is introduced, with illustrations from football player, weighted toy, etc. On commencing the exercise, the apparatus is shown, and detailed directions for balancing the irregular lever, hanging on the known weight, balancing again, and calculating the weight of the lever, are given. The class is then told: "It is possible to devise a check upon your result in this experiment. Think of a way in which you can prove whether the weight determined by calculation is actually the correct weight of the lever." This produces a suggestion that the lever be weighed on the spring balance. It is then explained that the spring balance is less accurate than the platform balance, which is thereupon shown, and its operation made clear. The class then use the platform balance to check the results obtained by calculation, feeling an interest in the fact that there is such an instrument, and deriving satisfaction from the ability to check their results accurately.

Perhaps these illustrations are sufficient to develop the point. In a series of experiments on specific gravity, involving determinations for both solids and liquids, I have found it possible to carry out the same idea of letting the pupil suggest means and devise methods. I have seen pupils select apparatus and invent procedures which gave the desired results, but which differed materially from any that lay within my own experience.

I judge the advantage of the procedure to be that it gives the opportunity, at least, for initiative to each pupil. Not every individual will be able at the first attempt to embrace the opportunity fully, but I have found that as the work goes on an increasing number develop this ability; and I have been astonished at the results obtained in interest and grasp.

I find my theoretical justification in a passage from John Dewey's *Moral Principles in Education,* which perhaps I may be permitted to quote. "The child cannot get power of judgment excepting as he is continually exercised in forming and testing judgments. He must have an opportunity to select for himself, and to attempt to put his selections into execution, that he may submit them to the final test, that of action."

## A NEW FORM OF FREQUENCY METER.

By N. F. Smith,
*Centre College, Danville, Ky.*

The writer was engaged one evening with his boy in the scientific diversion of spinning a top under the light of the tungsten lamp upon his desk. The top consisted of a white enameled disc upon which was painted the form of a red devil. He was interested to notice that as the rate of spin of the top diminished, the devil apparently stood still for an instant and then commenced to rotate the other way. It was immediately evident that here was a stroboscopic effect produced by the intermittent character of the incandescent light. Since the speed of the top could not be controlled, it occurred to the writer to modify the experiment by mounting on the shaft of a small motor of variable speed, a circular disc of white cardboard, on which were drawn four dark sectors, ninety degrees apart. This disc was strongly illuminated by the light from an A.C. arc with the carbons placed rather far apart. The effect, which had been faint and indistinct in the case of the top and incandescent lamp, now appeared with perfect distinctness. As the speed of the motor increased, a rate of rotation was found at which the sectors drawn upon the disc stood still or commenced to rotate slowly backward. By adjusting the resistance in series so that the speed was a little too high, the finger could be used lightly as a brake upon the shaft, and the speed held very constant at the desired value. The motor used was provided with a revolution counter by means of which the total number of revolutions in a given length of time could be recorded.

The light of the arc comes principally from the positive carbon and hence reaches a maximum value once in each cycle. It is evident, therefore, that the slowest speed at which the disc can appear at rest is such that it has rotated through one quarter of a turn in each cycle, or the number of cycles is four times the number of revolutions per second.

The same arrangement of apparatus is admirably adapted to show the intermittent character of the light in a vacuum tube illuminated by the discharge from an induction coil, and to determine the frequency of the coil. A determination of the frequency of an alternating current by the above method and by the method described by Kuehne (Vol. 10, page 24 of this journal), with a comparison of the results, is an interesting and profitable laboratory exercise.

## REVISED REPORT OF THE BIOLOGY COMMITTEE OF THE NATIONAL EDUCATION ASSOCIATION COMMISSION ON THE REORGANIZATION OF SECONDARY EDUCATION, TO BE PRESENTED, AFTER DISCUSSION AND REVISION, TO THE REVIEWING COMMITTEE OF THAT COMMISSION.

### I. Introductory Statement.

The leading features of this report are (1) its argument for a two-year course in elementary science planned as a whole, and (2) its suggestions as to ways in which such a course may be arranged to suit the needs of various localities.

The prevalent practice of organizing elementary science into separately planned one-year units is unsatisfactory. Many kinds of one-year units have been tried as first science courses, and none of them has proved wholly satisfactory. No plan, in our opinion, will prove satisfactory until a better organization is planned for meeting the needs, both as to content and as to method.

Such allotment of time as we propose has already been made, if we take into consideration the eighth as well as the ninth grade. Semi-departmental teaching in the eighth grade, especially under junior high school organization, has provided the opportunity for continuous work in elementary science in grades eight and nine. Thus our report does not propose more time for science than is already allotted in many schools; it merely proposes that this two years of work be planned as a whole and not as separate units. It does, however, call for more attention than is commonly given to organizing this work.

Science is the only major high school subject in which attention has not heretofore been given to the planning of courses more than one year in length. With the opportunity now afforded to bring about a more intimate relationship between the eighth and ninth grades, we believe that serious attention will be given to the principle of "two years, planned as a whole."

The popularity of general science proves the need that is felt for wide scope of subject matter. General science places no limit as to scope, but this enlargement of scope has rarely been accompanied by enlargement of time. This we believe to be unfortunate. We propose to extend general science into a two-year plan, so that thereby its values may be more fully realized, and that correction may be made of the shortcomings due to congestion of subject matter and consequent superficiality of treatment. The theory of general science—the theory of a general

acquaintance of nature to be acquired through experience and interpretation by scientific method—this theory we heartily endorse. But the practice of attempting to carry out this theory in a single year of work appears to us destructive of important educational values.

## II. Aims in Elementary Science.

In the following sections, the committee has set forth an argument for a course in elementary science which, in their judgment, meets the administrative and pedagogic needs of the situation.

As we were completing the revision of our report, we received the published report of the Committee on Program of Studies of the Illinois High School Conference, adopted November 20, 1915. The statements of that committee are thoroughly in harmony with our own views, and with the permission of the chairman, Dr. W. C. Bagley, we have incorporated in our report the conclusions of the Illinois Committee.

In order that the purport of our argument may be clear, the following aims in elementary science are stated, and in a parallel column we have placed corresponding aims that appear in the committee report to which we have just referred.

| *Statement of Aims as Expressed by Biology Committee.* | *Statement of Aims from Illinois Report.* |
|---|---|
| 1. It should arouse interest in nature, by giving boys and girls first-hand acquaintance with their environment. | 1. It should acquaint the pupil with those facts and principles of natural science, primarily through the use of environmental materials, to the end that he may understand and appreciate the objects and forces with which he comes in direct and frequent contact. |
| 2. It should emphasize some of the most important applications of science to human welfare, and especially should familiarize the pupils with the structure and functions of their own bodies to the end that they may know how to live healthfully and happily. | 2. It should acquaint the pupil with those facts and principles of natural science that have outstanding value, either because of their wide application to the problems of daily life or because of the important role that they have played in the development of civilization and the consequently significant part that they play in the thought and action of this generation and of future generations. |
| 3. It should give pupils some training in careful observation and in forming logical conclu- | 3. It should utilize among other methods of teaching that method which emphasizes the solution |

| | |
|---|---|
| sions, through the solution of problems, and the carrying out of projects. | of problems and the carrying through of unified projects, to the end that the pupil may be led to appreciate the value of scientific knowledge as an instrument in the solution of human problems and to the end especially that the pupil may gain through actual practice some initial skill in scientific method, and a keen appreciation of the value of this method. |
| 4. It should make real to the pupils the value of intensive study of any given science as a means through which scientific progress is attained. | 4. It should serve as an introduction to the more intensive study of the special sciences, but<br>5. It should also be organized and administered with the distinct recognition that it will be the only course in natural science, as such, that a large proportion of the pupils will pursue; consequently, it should represent, especially in content, the types of educative outcomes that are peculiar to the natural sciences and which, in the well-rounded education of any individual, are essential to complement the outcomes which are sought in other subjects. |

## III. How These Aims May be Realized.

This committee offers the following program for organizing a two-year course in elementary science in accordance with the aims just stated:

1. Where the junior high school is in operation, we suggest that this work follow the seventh year work in geography, and continue through the eighth and ninth grades.

2. Where the junior high school does not as yet exist, we suggest that the nature study of the eighth grade be continuous with the science work of the first year of the high school, and that it all be organized as a single course under the general supervision of the high school teachers.

3. In general, we suggest that there be a study of physical environment, plants, animals and man.

In view of what science has meant to our present-day civilization, in view of the measure in which the method and the results of scientific investigation are today reflected in intelligent thought and intelligent action, the right of natural science to rank as an indispensable element in the culture of all the people cannot be ignored.

Lack of coordination in the various branches of science as at

present taught, failure to teach definitely the underlying principles of science, and to relate these principles to life, are some of the criticisms aimed at our present-day science teaching. We believe that this is due in the main to poor teaching and to the organization of science into separately planned year units.

The aims stated above and the correction of the defects just cited call imperatively for a longer time for elementary science, and we believe that this should be a two-year minimum. Mere extension of the time limit, however, will not correct the teaching defects, nor allow the desired ends, unless provision is made for unifying both the content of the course and its pedagogical direction. In this connection the Illinois Committee states its conclusions as follows:

> The committee believes that the organization of a course in elementary science covering two years would be of large value in the solution of the science problem in the public schools. . . . . Where the intermediate or junior high school has been introduced, the committee suggests that the organization of such a two-year course in elementary science be carefully considered for the eighth and ninth grades. We believe that it may likewise be practicable in other systems where the eighth grade work is departmentalized. It could perhaps be offered in the ninth and tenth grades of small high schools where courses in the special sciences are impracticable. . . . .
>
> As a general introductory course specifically designed for relatively immature pupils, it will emphasize the practical, concrete applications of the scientific method and of the important principles that have been established through the employment of this method. The intricate and detailed study of natural science, involving abstractions that are remote from the pupil's experience and consequently difficult for him to understand and appreciate, will be left for the special courses in the later high school years.
>
> As a two-year course, it will allow a certain amount of organization in the sequence of topics, while, at the same time, it will afford ample opportunity for approaching every topic from the point of view of the pupil's needs, interests, and experiences; in other words, it will combine the advantages of the two modes of organizing educational materials that are sometimes contrasted under the terms, logical and psychological organization. In the opinion of the committee, an emphasis of either form of organization at the expense of the other would be unfortunate.
>
> It will permit a much more effective organization of the courses in the separate sciences offered as electives in the later high school years. With the preparation that this introductory course provides, and with the enrollment in the special courses limited to those pupils that have a distinct capacity for the more abstract and detailed study, the special courses could be made administratively equivalent to the introductory courses offered in colleges. In the belief of the committee, this would tend to terminate the present anomalous condition where we find pupils who have completed introductory science courses in the high schools compelled to repeat essentially the same ground in the college.
>
> While recognizing that opinions will differ widely as to the sequence of the larger topics in the course, and that much careful experimentation would be needed to determine the most effective sequence, the committee suggests as a tentative proposal that the course proceed from simple

inorganic phenomena to the more complex phenomena of organisms, culminating in the *study of man.* This sequence is roughly indicated by the terms, *physical environment, plants, animals, and man.* The marked advantage of this sequence procedure is that it preserves a continuity with the natural science materials that have been standardized under the general term, geography, in the elementary curriculum. Thus a start is made in a field in which the pupils have already had educative experiences.

The problem of elementary science teaching involves special factors that are not germane to advanced courses. In the latter, which will be in the main elective, we assume some previous knowledge, or experience, or interest, which directs the election. But all must agree that it is a most important function of first or elementary science courses to arouse or direct the child's interest to the phenomena of nature, and it is the feeling of your committee that this purpose is met by grouping this introductory treatment primarily about the applications of science to human welfare. To do this involves a preliminary investigation of the physical environment and, we believe, this can be accomplished successfully only through a required two year course, in which the first part of the course should show the necessity of science for explaining the adjustment of the individual to his environment, while the latter part should emphasize the manner in which physical and biological science has accomplished this task in various fields, leaving the pupil in later electives to pursue the matter and methods of special sciences, such as physics, chemistry, physiography, botany, zoology, or agriculture.

## IV. Content of a Two-Year Course in Elementary Science.

We wish to emphasize at the outset our conviction that the time has not come, and probably never will come, when a Science Committee is able to prescribe the *best content* for any course in science. Colleges and universities by their rigid entrance requirements, especially in physics and chemistry, have, in our judgment, seriously handicapped secondary school teaching.

Hard and fast requirements in either elementary or advanced science ought never to be fixed by any committee or by any higher institution, because of the wide variations of physical environment, fauna, and flora in Maine and California, in New Mexico and in North Dakota. Different types of courses should be given also in urban, suburban, and rural schools. Any work of the committee, therefore, along the line of formulating content should be accepted as an attempt to give a maximum of suggestion and a minimum of prescription.

Teachers should select material best adapted to local condi-

tions, should plan out in advance the work that is to be done, and should improve the course with each year of experience. In an agricultural community, special study should doubtless be made of the plants and animals of local economic importance. In communities engaged in mining or manufacturing, relatively more emphasis will be made on the study of the matter and forces in the physical environment. In large towns and cities, community sanitation and civic betterment will receive the major stress. Every child, however, whether in the country or the city, should be given such instruction in the care of his body and his mind that there will be a perceptible improvement in the health conditions and general efficiency of the community.

There are, however, certain general features that we believe should be stressed in all elementary science courses. Some of these are stated in the following paragraphs, and in the appendix we have suggested somewhat more in detail our ideas of a possible point of view in presenting the main facts of physical environment, plants, animals, and man.

In our preliminary report (published in SCHOOL SCIENCE AND MATHEMATICS, Vol. 15, 1915, pp. 44-53) we made the following statement:

> The preparation of an outline for teaching the part of the course in elementary science which deals with the matter and forces of the physical environment, together with the general applications of the principles of science to human welfare and convenience, awaits the cooperation of the other subcommittees in the sciences. For it is our hope that in the near future all the Science Committees of the National Education Association will unite and contribute of their best thought in constructing a course in elementary science so full of promise that no school can afford to omit the teaching of its universal principles.

We have been much encouraged by the promises of hearty cooperation on the part of other subcommittees in science, and we trust that before our final report is issued, the portion dealing with the matter and forces of the physical environment may be fully elaborated. Hence, in considering this report, prepared by the Biology Subcommittee alone, the reader should not be misled by any undue emphasis on biological factors that may seem to be apparent.

We believe that organisms should be studied from the point of view of: (1) Their relations to their inorganic environment and to each other; (2) their nutritive (or metabolic) functions; (3) their reproductive functions; and (4) the relations of each of the organisms studied to human welfare. (In the term,

"human welfare," we wish to include not only economic and hygienic aspects, but their æsthetic values as well.)

Too much emphasis can hardly be laid on noting the similarities and differences in the functions of the various types of plants and animals, including man. As the study progresses, tentative summaries should be made which will be later modified as need may arise.

Since, for a large number of students, this will be the only science course of the school curriculum, it is important that they get at least a very elementary conception of the great ideas relative to evolution, and some of the applications of this principle to human progress. Incidentally, they should be led also to appreciate something of the lasting indebtedness of mankind to great scientists like Darwin, Tyndall, Lavoisier, Harvey, Pasteur, Marconi, and Edison.

This committee feels that logical sequence and unity of subject matter are of great importance in any science course, elementary or advanced. It holds that only through such sequence and unity does a child or adult gain a clear vision of the underlying principles of a science. Such a procedure does not sacrifice the idea of interrelation between the sciences or of employing the project method. On the contrary, through the unity of the course, the idea that pursuit of any one science intensively must inevitably result in a general vision of all science is one of the most important results of this form of treatment. On the other hand, study of isolated phenomena almost inevitably results in a mass of informational material and a sacrifice of the very ideals that true science endeavors to inculcate.

## V. Methods of Instruction.

We do not believe in rigidity of method in teaching science. Observations, experiments, excursions, individual reports, textbook assignments, quizzes, conferences, are all good. They offer a rich and varied choice of pedagogical method, and each teacher should be given freedom to develop the methods best adapted to his students and to the environment of the school in which he is teaching.

In conducting field trips or museum excursions, the teacher should know in advance the best kind of material available and the use that is to be made of this material. Work in the laboratory should be planned so carefully that time is not wasted in too detailed microscopic work, in complicated experiments, in

too elaborate drawings, or in mere "busy work" to keep the children out of mischief until the end of the period.

All laboratory work should be attended by information ungrudgingly and interestingly given by the teacher, which should stimulate the student to seek more knowledge at first hand. Wherever possible, laboratory work on any given form should precede textbook assignments or library references, and since most high school students do not know how to use books effectively, these assignments and references should be very definite.

Experiments, results, conclusions, observations and drawings should be accurately recorded. Neatness in these records is desirable, but this should not be exalted above thinking and understanding what it all means. Careful labeling of drawings is important; careless spelling and ungrammatical sentences should not be tolerated.

We heartily approve of the use of the so-called "problem" or "project method" of teaching the various topics, whenever this method can be utilized without a sacrifice of the principles of unity to which we have already referred. Indeed, this method of instruction is commonly employed by every good teacher, no matter what his subject may be, as a means of developing and maintaining interest. We are confident, however, that courses that consist merely of a succession of more or less detached projects are quite likely to be lacking in both logical and pedagogical unity.

### VI. Possible Abuse of Laboratory Method.

The laboratory method in science was such an emancipation from the old-time bookish slavery of pre-laboratory days, that many teachers have been inclined to overdo it and subject themselves to a new slavery. It should never be forgotten that the laboratory is merely a means to an end—that the dominant aim in all laboratory instruction should be a consistent chain of ideas which the laboratory may serve to elucidate. The primary question is not what plant or animal *types* may be taken up in the laboratory, but what *ideas* are most worth while to be worked out and developed in the laboratory.

Too often our study of an animal or plant takes the easiest rather than the most illuminating path. What is easier, for instance, particularly with a large class of restless pupils who apparently need to be kept in a condition of uniform occupation,

than to kill a supply of animals, preferably as nearly alike as possible, and set the pupils to work drawing the remains? This method is often supplemented by a series of questions that are designed to keep the students busy a while longer.

Such an abuse of the laboratory idea should be avoided. The ideal laboratory is only a reasonably good substitute for out-of-doors. Any course in biology, when confined within four walls wholly, even if these walls be those of a modern, well-equipped laboratory, is in some measure a failure. Living things, to be appreciated and interpreted correctly, must be seen and studied in the open where they will be encountered in life. The place where an animal or plant is found is just as important as its shape or function.

In our judgment, relatively few plant or animal forms should be studied; but it is essential above all things that each of these plants and animals be supplied to the students, and that all possible work be done while the organisms are alive or when they are freshly killed. Experience has shown that young students usually lose an enthusiasm they may have had for biological study if they are compelled to work with preserved materials. In general, it is wise to study plant and animal material common in the environment; students can then collect a good deal of material and can also study its normal relations. We cannot emphasize too strongly our belief that mere textbook study of science has no place in this day and generation in an efficient system of education.

As Dr. Charles W. Eliot and other educational leaders have urged again and again, any laboratory exercise is unsuccessful in so far as it fails to develop right mental processes of observation and reasoning.

## VII. Suitable Equipment.

It is very desirable that a definite room or rooms be set apart for work in elementary science, since at least a minimum equipment is essential, and this cannot be transported from room to room without a considerable loss of efficiency. While it is desirable to have tables, or at least flat-topped desks of good size, satisfactory laboratory work can be done in an ordinary classroom if it is well lighted. The laboratory should, if possible, be equipped with a demonstration table and gas connections, with sink and running water, and a broad shelf should be placed in front of the windows for supporting growing plants and aquaria,

and for use in demonstrations with the compound microscope. Ample closet room should be provided in which to store apparatus and supplies, so that they may be kept free from dust.

Besides the test tubes, gas burners, and other apparatus usually obtainable from the physics or chemistry departments of the school or from the home kitchen, the minimum equipment for each laboratory should be one compound microscope, glass slides, and cover slips, together with a magnifier and dissecting needles, for each student. Botanical and zoological charts are very useful and many of them can be made by the students or by the teacher. An articulated skeleton can often be borrowed if the school does not possess one. The more experienced and the more skillful a teacher of science gets, the more different things he is able to do with a single piece of apparatus. We wish, however, to emphasize the fact that a course in elementary science can be carried on successfully without any large expenditure for apparatus or materials. *The most important consideration is that the course be conducted by a live teacher.*

VIII. Training of Teachers in Elementary Science.

The great problem in teaching elementary science—indeed, in all teaching—is that of securing teachers who are fitted in an adequate degree to do the work. In the judgment of the Committee, every high school teacher of science should receive preparation in higher institutions of learning at least along the following lines:

1. He should have a *broad knowledge of the whole field of natural science.*
2. He should know the aims and best methods of teaching science, and should be given an opportunity to acquire skill in presenting the subject.
3. He should have a grasp of the psychology and pedagogy of the adolescent.

It is therefore evident that prospective high school teachers of elementary science should have a training different from that of a candidate for the degree of Ph. D., where *research* along more or less narrow lines is a prerequisite. Dr. Thomas M. Balliet, Dean of the School of Pedagogy, New York University, in an article in the *School Review* of April, 1908, describes the present situation very clearly and suggests a remedy:

> The highly specialized training of the best graduate schools seems to make it difficult for the young teacher to view his work from the

standpoint of his pupils rather than from that of his subject. It is absolutely necessary that the chief interest of the teacher in the secondary school be in his pupils rather than in his subject, and the perennial source of interest in secondary school work must be in the new problems which each new class, and indeed each new pupil, presents, more than any researches which the teacher has the time and strength to make in his special field. A teacher in the secondary schools whose deepest interest is in his subject will find, after a series of years, secondary school work exceedingly disappointing and uninteresting. My contention is that graduate instruction in our universities does virtually nothing to fit a teacher to teach either science or mathematics in a vital way in secondary schools. It may even be possible that the highly specialized training of the graduate school, to a certain extent, unfits the student to do this sort of teaching. However that may be, I state a well-known fact when I say that not one in fifty of the men and women who take the Doctor's degree in science or in mathematics has the least conception of the problem before him when he begins teaching in a secondary school. . . . . I venture to suggest in a purely tentative way the following as possible (but perhaps only partial) remedies:

The graduate school may make a distinction between two classes of students, those who are fitting themselves to teach in universities and colleges, and those who are preparing to teach in a secondary school. . . . . The latter might be allowed to work in a broader field, to acquire a fair mastery of several related sciences, without being required to specialize narrowly, and be permitted to present a thesis which gives evidence of their having made themselves familiar with the methods of research in the subjects which they expect to teach, without requiring them to make any strictly original contribution to their specialty.

I suggest that the most important remedy would be to oblige every student in a graduate school who wishes to teach in a secondary school or in a college to study education, both as a science and as an art, and make himself familiar with the best methods of teaching the subject which he is fitting himself to teach. . . . . The rapid development of departments of education in our colleges and universities indicates that there already exists a wide recognition of the need of such training.

The committee would urge that the differentiation suggested by Dr. Balliet begin, if possible, even as early as the senior year of the college or university, and continue throughout the graduate work. It is hardly necessary to add that one of the most important elements of this training is ample opportunity for practice teaching *under the direction of those who have had successful experience in secondary school teaching.*

Science teachers already in service should be given encouragement by supervising officers and Boards of Education to add to their efficiency by wide reading, by visiting schools where good science work is being done, and by taking university summer courses in subject matter and methods of teaching.

## APPENDIX.

### *A. Physical Environment.*

The committee's general idea of the nature of the study of physical environment is as follows:

Study of the make-up of air, earth, water and soil, and the forces at work in the universe. This study should acquaint the pupil with the nature of his environment and emphasize the necessity of his adjustment to it. In selecting material for this part of the course, the guiding principle should be not merely to present information about nature, but to help the young student to realize the active changing world of which he is a part, and in which, by his own well-directed activity, he may guide his life properly. For this whole study finds its ultimate unity in the relations between physical environment and human life.

Many of the phenomena of nature form a part of our commonest knowledge. This knowledge, however, is usually fragmentary and unrelated. Emphasis should be laid early in this study on the constant flux and change in the physical environment, and on a corresponding flux and change in living things.

Matter appears in three states—solid, liquid and gas, and the same matter may appear in any one of these three forms. Water, for example, the chief liquid, becomes a gas or a solid under the influence of different temperatures. This universal liquid is of supreme importance in the environment of living things. The ocean affects climate, currents and winds. Acted upon by the sun, water rises from the ocean, in the upper air condenses, and pours itself out upon the land. It is the great sculptor of the earth's surface, and the vehicle of transportation of portions of the earth's crust. Water pervades the air, the soil, and the tissue of all living things. It is the great solvent and so becomes the food carrier in plants and animals, the waste-remover from living cells; hence it is important in all living processes.

In studying the atmosphere, we should consider some of the simpler processes—elements combining to form new compounds, compounds breaking up into elements. Attention may be called here to the combination of water and carbon dioxide in the process of photosynthesis. Some concrete idea should be gained relative to energy—how it has been stored through past ages and what is meant by its transformation and conservation.

Again, the solid particles of the soil are subject to constant change. They are transformed by the plants in the process of their nutrition and are in turn broken down by other plants and animals. Since the beginning of time, the same forces have been at work. A study of the stars, the solar system, and the earth's geological story teaches us how vast is the energy round about

us. The force of gravitation acting among the planets, the combination of elements in rock-formation, the changes when the earth's crust cooled and the atmosphere took its present character, the wonders of electrical and atomic energy—all these should be realized as manifestations of a changing world in which man has played an increasingly important part as fast as he has understood and made use of the forces that lie about him.

### *B. Plants.*

In introducing the study of plants, the teacher should be governed very largely by the environment in which he is working. Pupils are usually interested in the plant forms common around them; hence from the interest standpoint, this is the logical angle of approach. This first study should be in the nature of a general survey of the locality, and the pupils should thereby become acquainted with the names of common plants, the places where they are found, their distribution as regards the soil, the water supply, the elevation, their relation to one another in forming plant societies, and their economic values to man and to the animals associated with them.

This introductory survey should be followed by a more or less detailed study of the nutritive and reproductive functions of plants, both as a means of understanding the work of plants themselves, and as an introduction to these functions in animals and man. A special advantage in this early study of plants lies in the fact that these organisms lend themselves so readily to definite experiments and the conclusions derived therefrom can be reviewed and applied in the later work on animals and man.

### *C. Animals.*

Animals should be studied in a course in elementary science, not only because of their economic and æsthetic values, but also because the student thereby gets a clearer understanding of the structure and the functions of his own body. The forms selected for study should, as far as possible, be those common in the locality. Students should be urged to observe their habits and to collect some of them, and to note various adaptations for the life they lead. When this collecting is impossible, the various forms should be secured alive for laboratory observation.

In general, it is unwise to attempt any very detailed study of either external or internal anatomy. Instead, the students should be led to note the striking resemblances and differences in the representatives of the different groups studied, and especially to

study the way each important function is carried on by a given animal.

It is by no means necessary to consider the various animal forms in the order of their supposed complexity, or in accordance with tables of classification. Insects, for example, may well be studied first in the autumn when they are most abundant, and this work may be followed by a consideration of the birds that prey upon the insects. The number and the range of the forms studied will, of course, depend upon the time available, the environment where the work is carried on, and to some extent on the special interests of the students.

The teacher should first of all determine what are the *principles* to be taught and should then select his laboratory material with these principles in mind.

*D. Man.*

The committee is unanimous that the work in human biology should be closely correlated with a study of physical environment and with plant and animal biology and that emphasis should continually be laid on personal hygiene and sanitation. It is impossible to teach the laws of life of man, alone, out of the true relationship to the rest of life; but it is easy to teach these great laws of growth and development by studying the plants and animals and then tracing these laws up to man. Details of structure and anatomical terms should be given only when they are needed for an understanding of the given function, or for correlation with other parts of the course.

To present the various topics most effectively, a manikin and a human skeleton should be available. If, however, this is impossible, charts, pictures and blackboard diagrams should be freely used. Bones, joints, hearts, lungs and other organs available in a butcher's shop should be employed for demonstration. The student should always be led, however, to refer the various functions and hygienic applications to his own body, and care should be taken to see that few experiments are performed that do not have possibilities of this practical nature. Simple experiments with bacteria may be made especially effective in teaching hygiene and sanitation.

Whenever the teachers of physical training have adequate time and adequate preparation, it may be possible to incorporate parts of the work on human beings under that subject. Such a correlation of the work of the two departments makes for doubled efficiency.

Lists of topics suggested for use in the study of plants, animals and man will be found in our preliminary report, published in Vol. 15 (1915) of SCHOOL SCIENCE AND MATHEMATICS. We hope to include a revision of these topics, together with those on physical environment, in our final report.

In our judgment, there is no portion of elementary science that is of more importance to adolescent boys and girls than is the biology of sex. Unfortunately, this vital topic is almost wholly neglected by the average parent and few social agencies as yet see their way to give this much-needed instruction. It may be safely said, however, that no boy or girl reaches the age of fourteen without having received a considerable amount of sex information, information that is usually of a most distorted character and of unclean association. Most of these boys and girls long to find some one possessing the requisite knowledge who can frankly talk with them of adolescent experiences.

A rare opportunity is therefore open to properly trained teachers of biology who have the right point of view, of giving this much-needed help, for in this subject the approach to a discussion of sex is easy and natural and devoid of pathological aspects. An increasing number of good biology teachers are undertaking this phase of instruction, and the unsolicited testimony of youths and parents shows results from this natural approach, rather than from the pathological aspects, that are most encouraging. It is hardly necessary to state that when this instruction is given, the boys and girls should be taught in separate groups, and that the instruction should be given only by men teachers to boys and by women teachers to girls, teachers whom the students already know and trust.

Important, however, as is the teaching of the facts of reproduction and the hygiene of the reproductive organs, a knowledge of these alone is not very likely to keep boys and girls from bad practices when the time of temptation comes. "The inadequacy of mere knowledge in the realm of sex hygiene," says President Foster of Reed College, Portland, Oregon, "is painfully evident. To the *knowledge* of what is right must be added the *will to do* the right." Hence, in our judgment, all physiological instruction relative to sex should be supplemented and strengthened by sane appeals to the ethical and religious nature of boys and girls.

### ORGANIZATION OF THE BIOLOGY COMMITTEE.

In the autumn of 1913, Chairman Orr of the Committee on

Natural Science appointed the subcommittee, named below, to suggest the aims, the content, and desirable methods of instruction in secondary school biology. The committee as now organized consists of nine high school teachers, three college or university professors, three normal school instructors, and one physician. The geographical distribution of the committee membership is as follows—three members from New York and vicinity, five from Chicago and vicinity, three from New England, and five from the Pacific Coast.

During 1914-1916, ten meetings of the committee have been held in New York City, and the Chicago, the New England, and the Pacific Coast groups have had several conferences.

We wish to express our special indebtedness to Dr. Thomas N. Balliet, Dean of the School of Pedagogy, New York University, to Dr. Thomas H. Briggs, Teachers College, New York City, and to Prof. Charles E. Rugh, of the Education Department of the University of California, for their constructive criticism of both the preliminary and final reports.

The committee hopes that the publication of this revised report will lead both science teachers and administrative officers to consider carefully the suggestions herein contained and to send to the Chairman or any member of the committee a large number of constructive suggestions. The report will then be further revised before its final submission to the Reviewing Committee of the N. E. A. Commission.

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[1] In the death of its Secretary, Dr. Grace C. Cooley, in January, 1916, the committee suffered a great loss. Miss Cooley was one of the most active members of the committee. Her long experience as a teacher of first-year science, her great talent as a teacher, her thorough scholarship, and her charming personality combined in rendering her services to the committee invaluable.

[2] The death of Miss Lillian B. Sage in April, 1915, has been deeply felt by the committee. As head of the Department of Biology in the largest high school for girls in the world, she had wide experience, and her wise counsel has been sadly missed.

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## BARE WALLS AND MONOTONY.

The bare white walls of the modern sanitary hospital have a certain monotony which, in many instances, forms a dull and dreary aspect to the sick person who must lie for the larger part of every day and find nothing else in his horizon. A patient when he left the hospital, said: "Sister, tell the next patient who occupies this room that there are 391 fleurs-de-lis in the decoration on the wall." Another patient reported to his friends that his room was well aired by two large windows, that there were three flyspecks on the big white walls, and the brass doorknob was most interesting. In Indianapolis two units of the City Hospital, known as the Burdsal units in honor of the founder, have been decorated so adequately that the foregoing criticism does not apply. Some of the best artists—men and women of national fame—have collaborated in the work. In the children's dining room is portrayed a "festival of toys." In one of the corridors of the children's wards is illustrated the story of Cinderella. A well-known portrait painter has included twenty-four portraits of Indianapolis children placed medallion-like in panels between the windows. In the sun parlor the best-known children stories have been depicted in colors. A large bronze fountain is being made for the roof-garden playground. A visiting artist, looking over the walls already covered, remarked that there were only two buildings in this country that these decorations recalled, one of them, the Boston Public Library, the other the Congressional Library. The idea, while not wholly unique, has here been carried out with a quality and completeness probably not equaled elsewhere. As Brayton quotes, "These beautiful and peaceful decorations 'may minister to a mind diseased and pluck from memory a rooted sorrow.'" *The Journal of the American Medical Association* considers this achievement worthy of being widely copied if other communities can enlist a similar cooperation of artists.

## HOW CAN I TEACH GENERAL SCIENCE?

By John C. Hessler,
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Elsewhere the writer has expressed the conviction that a general science course can be given to large, first-year high school classes, with their varied needs, without specially prepared teachers and without expensive equipment for laboratory work. The present paper suggests some of the ways in which this may be done. There are some schools in which the equipment is sufficiently complete and the classes sufficiently small so that laboratory experiments may be performed by each pupil individually; there are other schools equipped for laboratory work with pupils in groups, say, of three or four; for our purpose, let us assume that individual laboratory work is impossible, that each class section must be taken as a whole and that the class can meet for one recitation period only in any given day. What can be done under such conditions?

Let us consider first the equipment of the teacher and of the pupil for work in first-year science. As to the *facts* needed by the teacher, the problem of general science is not so different from that of a special science. The teacher will need to become acquainted with the material of the subject: (1) by a review of the science of his preparatory school and of his college, or normal school course; (2) by a study of the textbook used for general science; (3) by reference to textbooks of the special sciences; (4) by reading articles in educational journals that have to do with general science. However, the chief difficulty will not be that the new teacher has not the facts of his subject (or cannot get them), but that he may lack the point of view of general science and thus may not see either its limitations or the opportunity that it offers. The teacher must remember that the young people of the first year of the high school are probably thirteen or fourteen years old, that most of them have had little, if any, systematic science work, that some may be afraid of the very word "science." On the other hand, as an offset to these difficulties, the teaching of young people of thirteen or fourteen has some tremendous advantages:

1. Students of this age have a real interest in the world about them—an interest that may be whetted to good purpose or allowed to grow dull by repression or by lack of exercise.

2. They have enthusiasm without the self-consciousness that

often characterizes pupils of the third or fourth year, at any rate under present conditions.

We may now ask whether this equipment of teacher and pupil is adequate for the purpose in hand. We do well to remember that successful teaching consists not merely in the adaptation of the teacher's mature knowledge to the immature student, but particularly in the securing of cooperation on the part of the student. The question is not so much "How shall I teach?" as "How can I help the pupil to learn?" It is not that the teacher shall answer the pupil's question nor that the pupil shall answer the teacher's question, but that the teacher shall stimulate the pupil to ask and to answer his own questions and to follow them, where possible, with some "activity."

If the motto of successful general science teaching should be cooperation between students and teacher, as the writer believes, when should the cooperation begin? Why not with the selection of the topics to be studied? The writer has actually seen work carried out in this way by a successful Eastern teacher. The selection may be made in a general way for the whole semester or term, and in final form for the month just ahead. Suppose that in the first class period of the semester, pupils are asked to suggest topics of everyday phenomena, or of housekeeping, manufacturing, or community activity in which they are interested and about which they would like to study. These may be written down by the students and by the teacher, duplicates and "nonsense questions," being eliminated. The pupils may be urged to ask their parents about topics for study; the cooperation of the home will thus be gained. When a considerable list of topics has been collected, the students may be asked to look over the table of contents and index of their textbook to see if the topics named are in the book and where. The teacher can then add topics to the list, word the topics as he wishes them, and arrange them in the order of the text; it is possible that he may wish to modify the order of the text or to suggest additional topics. In any case, he can submit the completed plan to the class for approval. If there are several recitation divisions of the class, the teacher can see that all the divisions have practically the same form and order of topics. This he can accomplish by a conference with representatives of each division. The teacher does not, in any of this, relinquish the things essential to his control of the class, or to the continuity of the course, yet the pupil has had his share in mapping out the work and has been set to thinking of

some of the things he would really like to know. A day or two spent in this way in planning the semester's work will repay many fold in interest, enthusiasm and accomplishment.

Now as to the study of a single topic—how may the teaching (and learning) actually be carried out? Suppose that the topic is: "What is matter?" or the related topic: "Is air matter?" The teacher asks each member of the class to suggest something that is "matter;" penknives, crayons, books, pencils, desks, our own bodies, apples, trees, lakes, stars, may be suggested. The fact that we know matter only as we know "bodies," or "objects," can thus be brought out. The teacher, or better, a pupil, can now try the effect of immersing several objects, such as pieces of marble, wood, lead, or glass in a jar or bottle partly full of water. If the jar is graduated, or has the original level of the water marked by a rubber band or gummed paper, the rise of water level will be noted. Instead of a bottle of water, one of compact sand may be used. By these means the teacher may draw from the class the conclusion that all solid bodies "take up room" or "occupy space." The teacher may now ask whether water, a liquid, takes up room. He may suggest that water be added to a vessel already partly full of water; the fact will be noted that the resulting volume will be the sum of the two. It is now time to consider the case of the air, a gas. Let a student try to pour water from a small-mouthed bottle and have the class note any peculiarity in the way in which the water comes out. Let the student also try to pour water *into* a small-mouthed bottle and to note that the water enters irregularly and that something escapes as water enters. The teacher or student may then try to pour water into a bottle, first through a funnel that fits tightly into the mouth of the bottle, and then through one that is loose. In this way, the class be made to see that water enters only as air comes out and comes out only as air goes in, also that vessels ordinarily said to be empty are full of matter, that is, of the invisible gas, air. The pupil can be asked to find utensils that make use of the fact that air is matter; the kerosene can, teakettle, coffeepot, all with loose covers, will suggest themselves, also the air vent in the steam radiator. Then attention can be called to the greater applications of the knowledge that air is matter—kites, windmills, pneumatic tires, sailing ships, and so on.

The topic of "matter" having been studied from the experimental viewpoint, together with what all the pupils, the text, and

the teacher have contributed, the pupil should be asked to prepare, from his notes, an essay or report describing what he has learned, including a description of all experiments carried out and of illustrations given to the class. This report will be similar to laboratory notes, but more complete in its form. The reports on the several topics are examined by the teacher, graded, and kept by the pupil or teacher until the end of the semester, when they are bound together as a notebook. Other topics following the one on "matter" may be worded in the ordinary way or they may be asked as questions, so as to give the exercise the form of a *"problem"* or *"project."* Illustrative questions are:

How do we get our units of length?
How do we get our units of weight?
Why do bodies fall to the earth?
Why do bodies have weight?
Why do planets revolve about the sun?
How are bodies set in motion?
How are moving bodies stopped?

Suppose that we consider in detail the treatment of another topic—capillarity. Let a pupil examine a long, clean, capillary tube and place one end of it in a glass of clean water. The result can be seen better if the apparatus is on the window sill rather than on the teacher's table. The water will, of course, rise in the tube. If the pupil puts a second capillary tube into ink or colored water, the rise of the liquid will be seen still more readily. Let the pupil select another capillary tube of different diameter and put it into the liquid and have the class note whether the water rises to the same height in the two tubes. They will reach the conclusion that the liquid rises to the greater height in the tube of smaller diameter. If the teacher has some mercury, he can place a capillary tube in it and show the class that in mercury a glass capillary tube does not cause a rise of level but a depression of the liquid. The teacher can show that water ascends between two plates of glass held close together, and that the nearer the glass plates are to one another the higher the water ascends.

The pupils can now be given an opportunity to think the experiment over and to talk about it at home. The next day they should be expected to bring to the class a list of as many phenomena as possible, in which water or other liquids ascend into solids or along the surfaces of solids, or are absorbed by solids. The teacher can also ask the class to prepare itself on what the

textbook has to say of capillarity. On the following day, the pupils will report their findings regarding the capillary behavior of liquids. Some will have thought of the rise of water into the boards or posts of fences or of houses, or into the brick foundations of houses, others will report the rise of sap and the absorption of water by towels and of ink by blotters, others still will have noted the rise of coffee into a sugar lump, and of kerosene into a lamp-wick. Some may have seen the rise of water into a heap of sand or earth. Each pupil should record all the cases named by all the members of the class. If the text suggests any additional experiments, these may be tried, if possible. Then, as in the case of other topics, the pupil should gather together the data contributed by his own experimenting or observation, by the teacher's demonstration, by his textbook, and by the other members of the class, and should embody it in an essay or report on capillary action. Topics like density, inertia, center of mass, atmospheric pressure, and so on, may all be treated in a similar way.

A word more regarding the teacher's demonstration experiments: they should be simple and direct; the name, construction, and operation of each piece of apparatus should be made perfectly clear to every pupil; pupils in the back of the room should come to the teacher's table so that they can see plainly what is going on; experiments should be repeated if the results are not understood by everyone; the teacher should enlist the help of the pupils whenever possible, and even permit them to carry out demonstrations independently. The time taken from the class period as a result of this demonstration work will vary with the lesson, but it need not interfere with the recitation proper. However, whether the time used be great or small, if the exercise results in the stimulation of thought and activity, it is well worth while.

The method suggested is, of course, only *one* way of teaching general science. The essential thing about it, in the opinion of the writer, is that it brings about the cooperation of the student; this is or should be the very foundation of all teaching. A second advantage of the method suggested is that the pupil has the subject matter of his topic outlined before he is asked to study from the book. The experiment becomes for him, as it is in fact, the point of departure instead of a remote illustration. And for his further illustrations he goes, not merely to the forms of laboratory apparatus but to the utensils and phenomena of every-

day life. There is nothing in the method that makes the text less valuable; rather does it make it the storehouse in which the pupil finds arranged, in orderly fashion, the fruits of the ages. The teacher may assign topics for review, use all summaries and suggestions, ask the pupil to prepare for recitation upon exercises, just as before. But, through all, the pupil feels that he is learning that which he has chosen to study, that science is a large field from which we can select only a few things for study in any one year, and that he may, if he chooses, go on in after years to the special fields to which the course in general science has given him the introduction. And if he does not go into a special science, he will still have, for the future, some slight appreciation of the meaning of science and confidence in those who, with their more abundant training, request him to help the community to a sane and efficient life.

## TO ILLUSTRATE BAROMETRIC PRESSURE IN CYCLONIC STORMS.

Into a large pail or tub, put water to about two-thirds of the tub's depth. Then set the water in rapid rotation by moving a stick or paddle around near the sides of the tub. This will, as is well known, cause a considerable depression of the water in the center. Then place one of the ordinary gauges, such as are used to measure differences in pressure, in the center, and at the edge where the water is highest and moving the fastest. A decided change in pressure will be noted.

## EFFECT OF IMPERFECT DIELECTRICS IN THE FIELD OF A RADIOTELEGRAPHIC ANTENNA.

The loss of electrical energy in an antenna is caused by the resistence of the antenna. The so-called radiation resistance is a measure of the portion of the energy usefully dissipated in the emission of electromagnetic waves. The remainder of the resistance causes a useless dissipation of energy that should be reduced to a minimum.

It has been previously noted that, in the region of the longer wave lengths, the resistance of an antenna increases with increasing wave length, and the explanation has been offered that this is caused by dielectric absorption or a loss of energy such as that which takes place in a poor condenser, and that it is probably caused by the ground. However, the Bureau of Standards, Department of Commerce, finds that the loss does not take place in the ground, but in poor dielectrics in the electric field of the antenna, such as wooden masts, trees, insulation, etc. Running the leads into a building may increase the resistance unless the interior walls are covered with metal screen and connected to the ground. It is important, therefore, to reduce to a minimum these sources of energy loss in designing an antenna.

The report on this subject is Scientific Paper No. 269, entitled, *Effect of Imperfect Dielectrics in the Field of Radiotelegraphic Antenna*, and copies may be procured, gratis, upon application to the Bureau of Standards, Washington, D. C.

## PRACTICAL WORK IN ARITHMETIC.

By Myrtie Collier,
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In attempting to outline the work of the elementary schools, one of the questions confronting the educator is how to bring the work into more vital touch with the life of the child, that he may have a real motive for doing things, and that through this doing, he may come in contact with certain great economic and social questions of the community in which he lives, and of the country as a whole. The importance of this question is intensified by the fact that many of our pupils leave school upon the completion of the elementary work. The only opportunity that the public schools have for training such pupils for efficient citizenship lies in the work of the grades below the high school.

In making arithmetic practical, two elements enter in: 1, the development of number, or the building up of a clear concept of number relations; 2, the application of the number facts to the quantitative side of the pupils' daily experiences.

There is a great waste of time in attempting to make arithmetic practical without first leading the pupil to develop the principles used in number work. The principles must be built on "number perception," and not on "word perception." The child is happy not only because he feels himself a discoverer in this development work, but also because he is the master of the principle and is able to apply it to his practical problems. Much is being done to economize both time and effort in the subject of arithmetic. Some superintendents are seeking this economy by omitting arithmetic in the first and second years; others, by giving little time to it in the first and second years and completing arithmetic in the seventh year, giving over the time in the eighth year to algebra. Practically all are eliminating those topics that are not practical, or are of little value to the great majority of people. While the writer is in sympathy with the movement to economize time in arithmetic, she does not feel that number work should be omitted from the first two grades, or that algebra should take the place of arithmetic in the eighth grade. Children need some number work in the first grade in connection with their construction work and in their games. So much practical arithmetic can be given to pupils of the eighth grade in connection with the civics work, the construction work, and the home work, or the family interests in which the boy or girl may be

deeply concerned at this period, that it might at least claim part of the time that is now devoted to the more abstract subject of algebra.

Much time would be saved if the school would cease the teaching of each operation as a separate, unrelated operation, and would establish a clearer realization of the purpose for which arithmetic is (or should be) taught. Mr. Courtis, who has made a broader study than any other investigator in the field of ability in arithmetic on the part of the pupils in American schools, says: "It seems practically certain that in the present state of our arithmetic teaching, each operation and each part or division of a topic is learned by the child as a separate, unrelated activity. There is no co-ordination, no appreciation of the meaning and purpose of arithmetic as a whole."—Thorndike's *Education*. When we have taught the principles of fractions we have taught the principles of decimals and of percentage. The latter are only special cases of fractions and should be so taught.

Another mistake, quite as serious as the lack of co-ordination in development work, is that of neglecting the application of number as we go. There is no formal subject in the grades in which the application can be made more easily than in arithmetic; and yet we often deceive ourselves by thinking that we have made our work practical by simply giving a list of unrelated problems in which the child fails to see the application because the problems are not concrete to him. Surrounding numbers with words in one long sentence, does not necessarily mean that the result is a practical or a concrete problem. A problem, to be either practical or concrete, must enter into the experiences of the child. If one cow costs $50, how many cows can be bought for $150? is not a practical problem for the mass of primary pupils, for they are not dealing with sums of $150, nor is the cost of a cow of any concern to them. If one toy costs $0.50, how many such toys can be bought for $1.50? may be a practical problem. The number combination is the same, and that is the object of the problem. In making problems, one should not lose sight of the fact that all our school activities should have an intimate relation to life, and should be performed because of that relation.

The business world, commercial and industrial, is striving for greater efficiency, or for economy in the expenditure of time and effort in producing a given result. If our arithmetic is to bring the child into touch with the quantitative side of commercial and industrial life, we must seek this same economy that the com-

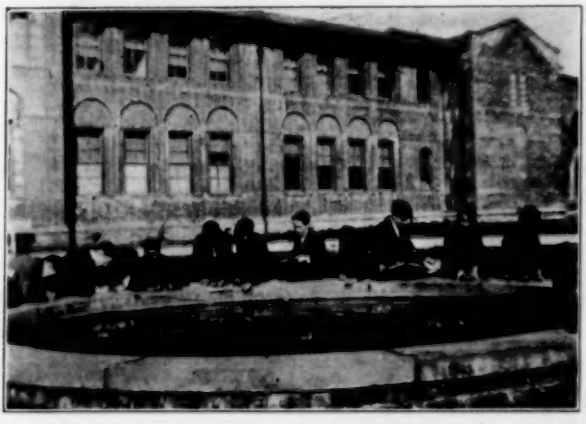
mercial and the industrial world are seeking, both in the operation and the application of number. In other words, "whatever pretends to be practical in arithmetic must really be so."—Smith's *Teaching of Arithmetic*. The subject of interest, for example should be taught as interest exists in the business world. No teacher should feel that she has done her duty with this subject when she has taught the six per cent method, the day method, the cancellation method, and as many more methods as the textbook may contain, and has left out the vital thing, the concept of interest and the effect of interest upon industry and trade. If the subject is taught in a city where banks lend money for a short term and collect the interest at the end of each month, all the time should not be spent in finding interest for periods of years, months, and days. Children of the upper grades should be led to see that rent is a form of interest, a dividend on stocks is a form of interest, income from a savings account is interest, and that money cleared on any investment is a form of interest. Such a procedure will make interest practical.

The concrete problem serves two important functions. The one is to introduce or lead up to a new topic, and the other is to drill in the application of number. The solution of the concrete problem calls for deductive reasoning. Children in the lower grades can do little deductive reasoning, but they can do "rational reasoning," if the content of the problem has meaning to them. To give this meaning, it is often necessary to localize the problem. Therefore, a certain amount of local arithmetic should be outlined in every course of study. The textbook writers are doing all that lies in their power to meet the changing needs of society; but since the mathematical foundation is the same in all cases, the material content of the problem should vary with the locality and should be supplied by the teacher and pupils. In other words, it is not necessary to discard the textbook in localizing arithmetic. In many of our better texts, the type of problem given may be used, but the real prices, the necessary measurements, etc., may be substituted to make it possible for the child to use "rational reasoning" instead of pure deductive reasoning.

Child psychology plays a greater part in the attempt to localize arithmetic than the substitution of mere number just mentioned. The per cent of phosphoric acid in the composition of a wheat fertilizer is a good problem in the study of percentage in certain rural districts, but it has little or no value for city children. The point to be observed here is that the child is able to think and

does think about matters connected with his environment. The teacher is the guide who is to lead the pupil to interpret his surroundings, and thus to create within him the "desire to acquire more knowledge for himself and to use this knowledge in an efficient manner." Touch the child's number interest and you have opened the door of problem work in arithmetic. Have the pupils of the class make problems, and you will soon discover what their number interests are. Furthermore, pupils love to solve problems made in class.

There are two dangerous points to be avoided in localizing arithmetic in the upper grades—1, the work should not be so simplified that the deductive reasoning is lost, or becomes negligible; 2, work which is arithmetical in nature but really belongs in some other subject or field should not be put into the arithmetic. We now have several excellent texts on practical arithmetic, as farm arithmetic, shop arithmetic, and others; but much of the work given in these books should be offered in a course in practical agriculture or in the shop, thus giving over the time in arithmetic to a more formal drill in abstract number, and at the same time affording the application in other fields of work. There is quite as much danger of neglecting drill in arithmetic as there is danger of neglecting the application of number.



In the work in the seventh grade of the Training School of the Los Angeles State Normal School, we have attempted to bring the work in arithmetic a little closer to our pupils this year by giving them a first-hand contact with actualities. We segregated the boys and girls, and by a close study of the pupils in each group, we attempted to give them number work based upon subjects of interest to a large part of the group. The boys' work

began with their shop problems in manual training. Next was some field work involving measurements of cement walks that were being put in near the building, to estimate the cost of the walks. The price per square foot, and the different per cents of ingredients in the cement were secured from three different cement companies. Part of the data was collected by the boys.

For our construction work, the boys estimated the cost of building a garage. First they made a scale drawing or a "blue print." They estimated the amount of lumber, and of cement work necessary for the construction of the building, and computed the cost of labor. At this point, discount was introduced because the boys needed it to find the net cost of the lumber. They made out lumber bills and discounted them. This gave a basis for studying different forms of bills and simple accounts.

Most of the time in the seventh grade is given over to the subject of percentage. We have attempted to make this phase of our work practical through "dramatization." The time is so great between the acquisition of facts and the application, that we feel that dramatization or play is necessary to connect what the pupil learns with what he does. For example, we introduced the subject of insurance by insuring the garage. When once they were interested in insurance, we studied life insurance, putting stress upon the importance to the father of carrying an insurance as a means of protection to his family.

One of the most interesting phases of the work in dramatization was the organization of a "play" bank in the classroom. We elected officers, secured a charter and sold stock, each child purchasing, through a broker, a number of shares. We secured from

banks in the city, blank forms of checks, notes, drafts, deposit slips and a few bank account books, which were used in the classroom. Later, the corporation was bonded, dividends were declared, and all the workings of the bank were participated in by each child. The children were encouraged to go to a bank and learn what they could about the business as it is conducted in a place of business. They were very much impressed with the idea that each man was attending to his particular duty and that there was no confusion. There was no question of discipline in our "play" bank, for the children said, "We wish to conduct our bank as the men in the bank conduct their business."

The day after we had studied stocks, one boy came early to tell the teacher that he had received some stock certificates for a present. He had thought of them just as pieces of paper, but now he knew their value and was anxiously waiting for his dividends.

The work with the girls has been quite as interesting as that with the boys. The girls' work has been based upon home economics, and the arithmetic of the home. The subject of percentage has been taught, in so far as we could teach it, as it relates to the economics of home life.

Through it all we have never ceased to drill and review pure number, but we have tried to carry out our idea of having such work as seemed to be practical, really practical to a large part of the class.

The business world is saying to the schools, "Give us clerks who can make out a bill and receipt it, assistants in the bank who can compute simple interest with accuracy, and bookkeepers who can keep books." The heads of homes should be saying, "Give us house managers who can keep a family expense account, who can estimate the cost of a meal, who can read the gas meter, and who can shop economically." It is this practical side of life that needs more attention in our number work. Mathematics is not too sacred to be used. Arithmetic should be treated, not only as a science, but as a science applied to practical living.

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## A MATCHLESS LABORATORY.

We use "Pyro Lighters" instead of matches. They come from Haverhill, Mass., but can be bought in any hardware, department or ten-cent store. Extra fillers cost five cents. We provide one for each four desks and after several years experience, we cannot say enough about their convenience, economy, and cleanliness.

## MATHEMATICS RELAYS FOR HIGH SCHOOLS.[1]

By Ernest H. Koch, Jr. and Thomas H. McCormick,
*High School of Commerce, New York City.*

One of the most hopeful signs for the advancement of secondary school education is reflected in the increased attention which is being given to the content and instruction of the first year work in high schools. To those who are concerned with this work, it is always a source of interest and profit to note and measure the development of pupils during this formative period. It is a well-known fact that a test given to an entering class of high school freshmen will show it woefully lacking in any sustained arithmetic operation. It is for this reason that every high school course in mathematics should provide for a resumption of the elementary school drill for a period extending from five to ten weeks. The manner of presenting such a drill will depend

Test 1: Addition.

| (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|
| 869 | 494838 | 67949574 | 369231 | 168.29 |
| 675 | 489614 | 83357111 | 445170 | 1175.59 |
| 534 | 429868 | 23736625 | 233068 | 935.48 |
| | 793597 | 22165242 | 320122 | 27.61 |
| | | 42776566 | 382428 | 872.29 |
| | | 64111731 | 625552 | 1015.88 |
| | | | 717165 | 1322.37 |
| | | | 441314 | 537.48 |
| | | | 514685 | 170.23 |
| | | | 761336 | 540.62 |
| | | | | 115.21 |
| | | | | 696.66 |
| | | | | 1006.33 |
| | | | | 653.96 |
| | | | | 177.87 |
| | | | | 28.53 |
| | | | | 262.71 |
| | | | | 691.14 |
| | | | | 104.12 |
| | | | | 282.93 |

(6) Add horizontally 369+284+795+306+155=

Test 2: Subtraction.

(1) 5782 3798 (2) 46928743 35847865 (3) 356478912 99999999 (4) 46386721467 34594677374

(5) From 4873925816 subtract 563872615 three times in succession.

Test 3: Multiplication.

(1) 62x36; (2) 848x759; (3) 78654x3.1416; (4) 86372417x624; (5) 75637x3x5x7; (6) 1425 lbs. meat @ 18¾ cents.

Test 4: Division.

(1) 365÷15; (2) 4638÷412; (3) 53896388208÷1147; (4) 120÷135; (5) 1.65÷.9.

Carry divisions to two decimal places.

[1]This article received and put into type in September, 1915.

upon the type of high school, the course, the character of the work presented during the first year and also upon the attitude of the pupils and their teachers. It is considered advisable to learn the status of the class during the first day of school instead of wasting this time before the formal instruction is begun. It is suggested that you try Tests 1, 2, 3, and 4 upon your classes in order to determine their sustaining power in the four fundamental operations. An arbitrary but convenient basis for rating is to assign to each example a weight corresponding to its position in the set. Credit should not be given unless an example is completed without error. On this basis the maximum rating for six questions is 21. It is comparatively easy to arrange a set of examples so that the total operations in a particular example may be commensurate with its position in the set. The four tests may be given during one hour, allowing a five-minute interval between tests.

Many high school teachers realize that the pupil's reluctance to continue arithmetic is due to the failure to provide expedient methods for maintaining interest in the subject. It is the purpose of the authors to present from their experience a simple successful device which maintains the interest in arithmetic in a most unexpected manner and at the same time provides the most desirable incentives for accuracy and speed in the fundamental operations. This device is in the nature of a contest and is called a Mathematics Relay because it was first used as an event in an intellectual Three "R" Contest which was conducted like the usual athletic track meet.

The relay consists of four related parts presented in the following order—a continued addition, a continued subtraction, a continued multiplication, and a long division. It is performed by four boys who constitute a team. Each boy performs one of the operations and when he has finished, the next boy follows him, and so on until all of the operations have been completed.

In order to have the entire class participate in a relay, the class is divided into as many teams as there are multiples of four boys. The class teacher either selects or calls for volunteers who act as captains of teams. Each captain selects three other members to act with him as a team. If a class exceeds forty in number, allow five members to a team, in which case one boy in each team serves as an alternate.

All teams begin work simultaneously at the blackboards upon a signal from the teacher. The blackboards at the front of the

room are adequate for this purpose and can be seen easily when the teacher is stationed at the rear of the room. The winning team is the one which finishes first with a correct answer. A member of a team may fail to do his assignment correctly and after two more vain attempts at a correct solution he is replaced by the alternate designated by the captain of the team. If the alternate fails in three attempts at the same assignment, then that team forfeits its place in the contest. If the captain fails, a new captain may be chosen and he in turn reorganizes his team.

At the beginning of a contest the captains write on the boards the subtrahend (S), and how many times it is to be used; the multiplier (M); and the divisor (D), similar to the following:

| S 98645, 5 times | M 6, 8, 9 | D 432 |
|---|---|---|

The captains then retire and send their respective adders to the blackboards and at a given signal the latter write two addends dictated by the teacher. Without any further direction, and unaided, they proceed to form eight additional addends and finally sum the entire set of ten addends. The method of forming the additional addends is shown in the work below. The principle is to add two successive addends to form the one following as shown:

| | | |
|---|---|---|
| Addend (1) | 34786 | Dictated by the teacher |
| Addend (2) | 59301 | Dictated by the teacher |
| Addend (3) | 94087 | (1) + (2) added by the pupil |
| Addend (4) | 153388 | (2) + (3) added by the pupil |
| Addend (5) | 247475 | (3) + (4) added by the pupil |
| Addend (6) | 400863 | (4) + (5) added by the pupil |
| Addend (7) | 648338 | (5) + (6) added by the pupil |
| Addend (8) | 1049201 | (6) + (7) added by the pupil |
| Addend (9) | 1697539 | (7) + (8) added by the pupil |
| Addend (10) | 2746740 | (8) + (9) added by the pupil |
| Sum | 7131718 | |

A teacher's check which is not to be given to the pupil under any circumstance is to multiply the seventh addend by the number eleven.

When the teacher nods his head indicating a correct result, the next boy of that team goes to the board and subtracts the subtrahend the required number of times from the previous boy's result.

| | | |
|---|---|---|
| Minuend | 7131718 | (previous sum) |
| Subtrahend | 98645 | |
| | 7033073 | first remainder |
| Subtrahend | 98645 | |

| | | |
|---|---|---|
| | 6934428 | second remainder |
| Subtrahend | 98645 | |
| | 6835783 | third remainder |
| Subtrahend | 98645 | |
| | 6737138 | fourth remainder |
| Subtrahend | 98645 | |
| | 6638493 | final remainder |

When this work is correct the third boy goes to the board and does the required multiplication, using the last boy's result as the multiplicand.

| | |
|---|---|
| Multiplicand | 6638493 |
| First Multiplier | 6 |
| | 39830958 |
| Second Multiplier | 8 |
| | 318647664 |
| Third Multiplier | 9 |
| Product | 2867828976 |

Finally, the last boy of the team goes to the board and divides the product obtained by his team mate by the required divisor written at the top of the board.

Divisor Dividend
432 | 2867828976
6638493 Quotient.

That team which completes the work correctly in the least time is declared the winner and the champion of the class. A series of challenges follows and with the reduction in the time limit of contests, the classes are able to form a challenging team to meet similar teams from other classes. By the process of elimination an all-school team is chosen and this team represents the school in inter-annex or inter-school contests.

The development of relay teams involves from five to ten minutes' drill daily during the arithmetic class period if there is one, otherwise it may be conducted by the official teacher or section officer during a study period. It needs no further comment to say that once relays are started the pupils will take care of themselves for practice whenever they may have the privilege to use blackboards before, between and after school sessions.

Incidental to these relays are the separate drills in the four fundamental operations, each of which provides opportunities for contests. They are important in themselves and become interesting because they are contributing factors to the relays.

Addition drills are always more interesting when they involve the formation of addends from two given addends and the subsequent summing of all the addends. It is wise to begin addition with numbers of the fourth order and gradually increase their magnitude until numbers of the ninth order are used. It is also desirable to limit the number of addends to six at the beginning and then rapidly increase this number to ten addends. For general class drills in addition, the following order of difficulty is suggested. The number to the right of the two given addends indicates how many addends are to be used for the sum.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 375 | | 8724 | | 88509 | | 76549 | |
| | 6 | | 6 | | 6 | | 10 |
| 246 | | 9437 | | 24763 | | 28763 | |

Drills in subtraction require that a given subtrahend shall be used repeatedly and successively a definite number of times. It is the reverse of the process of addition described above, excepting that the same operator is used.

Drills in multiplication involve two or more consecutive multiplications in which the multipliers are chosen from the nine digits. Variations are made by repeating the multipliers in different arrangements.

Drills in division involve a single divisor of low order. When the quotient is not integral, it is required to express the remainder as a fraction in its lowest terms. Long division should be done directly without partition of the divisor. It is interesting to make the divisor the product of the multipliers of a previous multiplication example, at the same time using the previous product as the new dividend.

If the teacher has a ready command of numbers he can dictate operators at random and obtain his answers for checking by short cut methods.

An easy way to obviate the desire on the part of some pupils to cheat is to use a 6x9 yellow pad for drill work. After the sheets are distributed to the class, each pupil is instructed to fold the paper into quarters. This provides eight spaces, each space being reserved for a single example. One space may be used for the date, name, class, time consumed in test, and the grade. Designate each of the eight spaces by number and dictate the operators for each example, designating the space into which it is to be placed. When all the dictation has been made, have the papers folded, exposing space one. At a given signal have the pupils blaze away but always keeping the papers folded to the space in which they are working. This makes a fool-proof de-

vice which entirely eliminates opportunities for dishonest work. It should require less than a minute to distribute paper and dictate the examples. At first it will require about two minutes for each example but this time may be cut in half after a week of drill and should be reduced considerably but less rapidly after five weeks' drill. A relay such as is shown in this article should be completed within five minutes.

The following material has been used in the classrooms of the authors and will be found of great service as the answers accompany each example. The examples in addition all involve ten addends. The subtraction examples all involve a repetition of the subtrahend five times. The separate multipliers are indicated by the commas which separate them.

ADDITION.

| | | | | |
|---|---|---|---|---|
| 34786 | 54732 | 76592 | 76459 | 17809 |
| 59301 | 83196 | 31480 | 95467 | 37211 |
| 7131718 | 10331508 | 6982800 | 12606341 | 4254063 |

SUBTRACTION.

| | | | | |
|---|---|---|---|---|
| 7131718 | 10331508 | 6982800 | 12606341 | 4254063 |
| 98645 | 45678 | 78692 | 82821 | 54063 |
| 6638493 | 10103118 | 6589340 | 12192236 | 3983748 |

MULTIPLICATION.

| | | | | |
|---|---|---|---|---|
| 6638493 | 10103118 | 6589340 | 12192236 | 3068994 |
| 6, 8, 9 | 5, 7, 9 | 4, 7, 6 | 7, 7, 7 | 8, 3, 5 |
| 2867828976 | 3182482170 | 1107009120 | 4181936948 | 368279280 |

DIVISION.

| | | | |
|---|---|---|---|
| 432 \| 2867828976 | 315 \| 3182482170 | 672 \| 107009120 | 196 \| 4181936948 |
| 6638493 | 10103118 | 1647335 | 21336413 |
| 144 \| 368279280 | | | |
| 2557495 | | | |

The following examples are appended for relay work but it should be noted that the examples listed above may be combined to make relay examples. In each case the addends are to be used ten times and the subtrahend is to be repeated five times.

RELAY EXAMPLES.

| | | | |
|---|---|---|---|
| 47591 | 34752 | 74289 | 93897 |
| 24863 | 76828 | 35927 | 47095 |
| 4805449 Sum | 8672224 Sum | 7247471 Sum | 9308695 Sum |
| 78963 Sub. | 84628 Sub. | 83927 Sub. | 79317 Sub. |
| 4410634 Rem. | 8249084 Rem. | 6827836 Rem. | 8912110 Rem. |
| 7, 5, 9 Mul. | 4, 8, 7 Mul. | 7, 9, 4 Mul. | 8, 7, 6 Mul. |
| 1389349710 Prod. | 1847794816 Prod. | 1720614672 Prod. | 2994468960 Prod. |
| 630 Div. | 896 Div. | 336 Div. | 672 Div. |
| 2205317 Quot. | 2062271 Quot. | 5120877 Quot. | 4456055 Quot. |

The authors are not aware that the mathematics relay has been

tried elsewhere before its introduction at the High School of Commerce in New York City. It will give the authors pleasure to learn the results of trials by other teachers. This device has demonstrated to business men at three public exhibitions that it is possible to train pupils in accuracy and speed in an effective and interesting manner and so that they may continue to maintain the highest respect for the technique of computation.

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## EARTH CRUMPLING WHICH FORMED MOUNTAINS.

In the region now occupied by the Wasatch Mountains, a number of parallel faults were developed close together, and the broken pieces of the earth's crust between them were pushed up, the rocks on one side of each crack riding up over those on the other side until a great mountain range was formed where once lay a plain. During the long period of slow earth movement which made these mountains, flat-lying parallel beds of rock were locally turned on edges, crumpled, and folded in a wonderfully intricate manner. These upturned and crumpled rocks are well exposed in Ogden Canyon. The west face of the Wasatch Range is believed to mark the plane of a normal fault at a nearly vertical crack in the earth's crust, the rocks on the east side of which went up or those on the west side went down. The forces which have raised these mountains are still active, for movement along this fault has disturbed the surface recently.—*Overland Guidebook, U. S. Geological Survey.*

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## CLASSROOM SAYINGS.

*Question*: When the magnetic poles of the earth were discovered, how did the people know when they were at the poles?

*Answer*: The boats were drawn to the poles, and the nails came out, and the boats spun around.

*Question*: State two reasons for calling carbonic acid a weak acid.

*Answer*: $H_2CO_3$ is a weak acid because it turns litmus a very faint red and because it is used in soft drinks.

*Question*: Name the different kinds of air in the lungs.

*Answer*: There are three kinds of air, complemental, supplemental, and ornamental air. One hundred cubic inches of air are in the lungs all the time. This is ornamental.

*Question*: Through what valves does blood pass in the heart?

*Answer*: The valves through which the blood pass in the heart are the glottis and the epiglottis.

*Question*: Why should the labels on canned goods be read?

*Answer*: We should read the labels on canned goods because they might say that they contained something we would not want in some obscure corner.

## THE TOPOGRAPHIC MAP.

By G. H. Oberteuffer,
*Junction City, Oregon.*

The use of the United States topographic maps in connection with a course in physical geography has become quite prevalent in our larger high schools. The benefits derived from the use of these maps are three, namely—to illustrate by actual example different kinds of topography mentioned in the textbook; to teach various topographic forms first-hand; and also to acquaint the students with this highly beneficial phase of government work. Preceding the first assignment or exercise on the maps, the teacher must explain the different methods of illustrating elevations on a plane surface, including a full explanation of the contour. A sketch on the board may be used to advantage, a basin of water, a lake in a sand table or a piece of string may also serve to make the idea clearer. To finish the discussion, the teacher will cite a simple definition, somewhat like this: "Therefore, students, we see that a contour is a line connecting all points of equal elevation." Now if, on the following day, the teacher should quiz the class on an explanation of what a contour is, she would in all probability get a definition like the above and no trace of an explanation. The definition was memorized, but the explanation went for naught. The day following one such explanation, I had one student tell me that a contour line was "a piece of string tied around a hill, even all around."

Another difficult thing about a map to explain is the scale. The average high school freshman cannot understand how an inch on a map may represent a mile of actual distance. He may know for a certainty that it does, but to memorize a fact and to understand a method are distinctly different. And all science teaching is leading away from the type of "poll-parrot learning."

These are just two of the difficulties encountered by the student in his use of topographic atlas. In looking at the sheet, he can see a great number of brown lines running crooked and, if he has had some experience with maps, he knows at once that if the lines are close together, there is a steep slope, and if they are far apart, the land is almost level, but how much more could he read at a single glance if he only had a good clear idea of what those crooked brown lines actually were. I visited a physical geography class of twenty in one of the larger high schools last

spring. They had been studying the maps for seven months. Upon being invited by the teacher to ask a question, I asked the class this, "Could contour lines cross?" They were divided. Three said no. Five didn't know. Nine said they could but they had never seen any that did, and the other three had seen them cross "lots of times." Evidently, those students were not getting the vast benefit which they might have derived from this study.

Now let me suggest a plan whereby the student will obtain a very realistic idea of a contour, a map scale, surface features, and also the United States geological survey and its work. The plan is in the nature of a laboratory exercise, after which the student can fully appreciate the meaning of every detail on the Atlas sheets. It's a simple thing, the easiest way in the world to have a child understand something. Let each child in the class actually make a topographic map. It sounds difficult and impractical, but I have given it very fair trials, and it has fulfilled every expectation.

The entire exercise will cover about ten periods of one hour and a half each. If a Saturday morning can be used, five addition double periods would suffice. I will assume that the Saturday is not available, and that we use ten double periods, starting on Monday.

The first thing is to tell the class what you intend to have them do. Briefly run through the proposed work, making it sound just as attractive as possible. Arouse the interest of the students. If they know of some big brother who is out surveying, let them tell about it, and then tell them that they, too, are all going to be surveyors. There is a certain fascination about surveying that will not fail to make its appeal in this case. Tell them also that you are going to make the girls work, and that the boys will have to hustle to outdo them as surveyors. Do not emphasize at first the actual map work to come later. Then the duties must be assigned. The offices will be as follows:

Transit Party: Transit man, head chainman, rear chainman, stake carrier, stake "puncher," note taker. Level Party: Levelman, rodman, head chainman, rear chainman, stake "puncher," note taker.

Two students may be assigned to each of the above-mentioned parts. In addition to this, you must appoint a chief engineer, an assistant engineer and a consulting engineer. The faculty member of the party might act in the last-mentioned capacity.

Next comes the assignment of equipment. The transit man must have three straight sticks about four feet long, pointed at one end, and a small hammer or hatchet. The chainmen must have a tape measure of some sort. For the chainmen on the transit party, a hundred-foot steel tape is advisable. A shorter one may be used by the level chainman. The stake carrier must have a gunny sack, about forty small stakes, smooth on one side and pointed at one end, and a lumber crayon. The stake "puncher" should help make the stakes and should also provide himself with a small hand ax. The levelman should have a small hand or field level. If these are unobtainable, a camera tripod and a carpenter's level will do. The rodman must have a rod about eight feet long, graduated to half feet and marked clearly. A piece $\frac{1}{2}'' \times 2''$ finished on one side will serve nicely. The note taker must have a notebook and soft pencil.

The following day some of the time may be given to those students who have not yet made or obtained their equipment, in order that they may do so. The rest of the class should start for the field of work. The faculty member might consult on the way out, with the three engineers, on the prospective tract to be surveyed. A piece of land about four hundred feet wide and one thousand feet long with a few changes in elevation is very satisfactory. Surface features, such as a creek, an irrigation ditch, woods, fences, wells, barns, houses, telephone poles, etc., are necessary. Talk over a few such tracts with the engineers and, in fact, with the whole party.

After one particular tract has been decided upon, explain to the students that it is first necessary to run a center line from one end of the piece to the other. This will be a line of stakes from which all measurements will be taken. It is unimportant to the final appearance of the map, but absolutely essential for obtaining your data or notes. Choose a starting point and have the stake "puncher" mark a stake 0+00 (the customary civil engineer's method of denoting the start of a line) and drive it at this point. Then gather the students at this place, show them the direction in which you expect to go. Then explain that the first thing the following day, the transit party will run the center line. This consists of setting a line of stakes fifty feet apart the entire length of the tract, and may include the turning of one or two angles.

Then explain fully to the level party that after this line has been run, they are to get the elevation of each station on cen-

ter line and also of each break in the slope at right angles from each station, for two hundred feet on each side.

Explain things fully to all the students and make each one feel that he is a part of the crew, and that upon the work of each individual depends the success of the enterprise. If time remains, let the students familiarize themselves with the use of the various instruments.

The third day, begin the work in earnest. The transit party starts off in charge of the chief engineer. The transit man drives one transit stick at 0+00 and another at the point to which you wish to work or at the point of the first angle of center line. Then let the chainmen chain fifty-foot stations, being kept in a straight line by the transit man's sighting between the two sticks. The stake "punchers" mark the stakes 0+50, 1+00, 1+50—, 2+00, etc., and drive them in the places designated by the head chainman. When they have reached the angle point, let the transit man go ahead to the proposed termination of the line or the next angle point, and there set his third transit stick. He then goes back to the apex of the angle between the three sticks and estimates the enclosed angle. The chief engineer should check his estimations, and then the consulting engineer should be summoned and pass judgment on the estimate. A small protractor may be used to good advantage. Then the line running goes on as before till completed.

Meanwhile, the level party in charge of the assistant engineer starts. A place whose elevation is known is chosen as a "bench mark" or starting place. This elevation may be determined from a United States topographic map of the vicinity. If a United States Geological Survey bench mark or triangulation point is near, this makes an excellent starting point. The rodman holds the rod upright over this point. The levelman, after choosing a point from which he can see all of the first section of the center line, and "leveling up," reads the rod. The rod reading, plus the elevation of the bench mark of course, gives the height of his instrument or H. I. At this point, it is necessary to warn the levelman not to move or change his H. I. in any way. When the H. I. is established, it is clear that a rod reading which subtracted from the H. I. will give the elevation of any point. A reading is then taken at 0+00. Then the rodman goes out at right angles to center line to the first break in the slope, and another rod reading is taken, the chainmen meanwhile getting the distance out. This is continued,

getting every break, for two hundred feet on the right and then the same on the left, always measuring at exact right angles to the center line.

The note takers will record their notes thus:

| Left. | | L. C. | | | | Right. | |
|---|---|---|---|---|---|---|---|
| 200 | 100 | 50 | 3+00 | 31 | 50 | 100 | 200 |
| 316 | 315 | 314.6 | 314.1 | 313.8 | 310.3 | 310 | 310 |
| 200 | 75 | 50 | 3+50 | 50 | 100 | 200 | |
| 316 | 316 | 315.5 | 314.6 | 314 | 312 | 309 | |

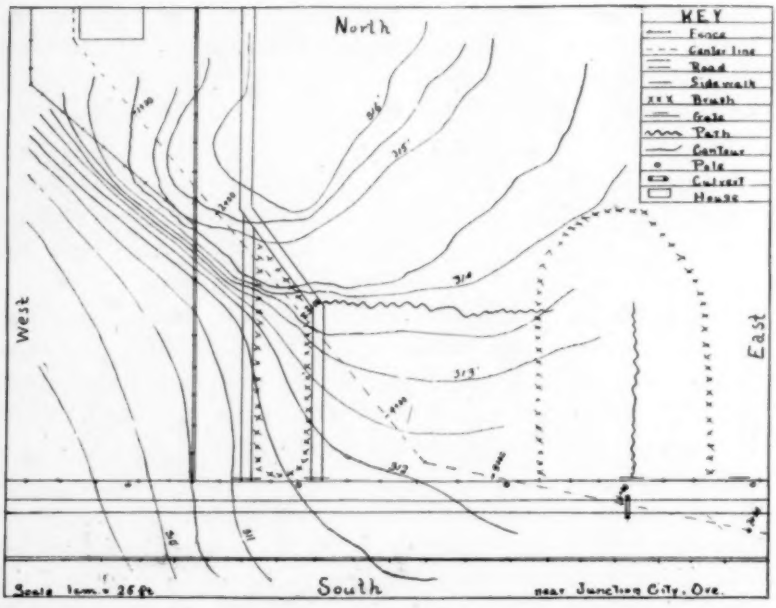
This, translated into words, means that at station 3+00 the center line elevation is 314.1; thirty-one feet right, the elevation is 313.8; fifty feet, 310.3, etc. The distance is called by the rear chainmen after each rod reading. The elevation is obtained by subtracting the rod reading from the H. I. The level party continues thus to the end of the line. They will do about four or five hundred feet in this, the third day.

The fourth day let the level party start where they discontinued the previous day. The transit party, having finished running center line, must start again at 0+00 and get "surface features." That is, they measure at right angles from each station and locate the above-mentioned fences, gates, sidewalks, phone poles, etc. If a fence continues in a straight line, two or three measurements are enough to locate it. If a gate is at right angles to center line between two stations, a station must be established between. Every surface feature, barn, brush pile, tree, ditch, culvert and path, should be carefully located.

The fifth day, the last field day, may be spent in finishing up. Let the engineers look over the notes, both transit and level, to see that nothing has been omitted. Let them reestimate the angles. Also, if any student has a question to ask on any part of the work, have the engineers explain fully the answer. Before leaving the field of operation, be sure that every student has a clear and definite idea of every detail of the work.

The next week is spent in actual map construction. Monday, the student should come provided with pencil, scratch paper, and a large sheet of graph paper. The teacher should then have the transit note taker dictate the transit notes, each student making a copy. Following is the form for the transit notes:

| Left. | | | Right. |
|---|---|---|---|
| 75′ | 0+00 | 50′ | 150′ |
| Pine tree | Start of center line. | Fence | Road |
| | 0+50 | | |
| | 0+60 | 30′/Brush heap | |
| 60′/Corner Barn | 1+00 | | |
| 75′/Corn. of Barn | 1+30 | | |
| | 1+50 | | |
| | 2+00 | | |
| | 2+50 | | |
| | 3+00 | 100′ | |
| | Fence | Road | |
| | 3+50 | | |
| | ∠ to L. 10° | | |




Then on the graph paper have the student mark the top N for north; the bottom S for south and sides W and E. Next, it is necessary to determine the scale. Have the students tell you how long center line is. Then how long the sheet of graph paper is. Supposing the center line is one thousand feet long and the graph paper twenty-five centimeters. It is then a very easy matter for the students to see that in order to get the whole center line on the page, every centimeter must represent forty

feet. Then the scale will be written in the margin 1 cm. = 40 ft.; now we are ready to plot the center line. This should be done in pencil and very lightly, down as near the center of the page as possible. Be sure and have the directions on the maps correspond to those in the field. Every other station may be located and labeled lightly. Then the code of symbols may be selected. As far as possible, the United States Geological Survey symbols should be used. For a brush pile ⊙ is good. For a telephone pole ‡ does nicely. A fence may be represented by ####, etc. After the code has been explained, the students should locate in light pencil the surface features. Caution must be used to measure in each case at right angles to the center line.

The following day, the students should be equipped with a ruler and another sheet of graph paper. The level note takers should then dictate the level notes, a copy of which is made by each student. Then the work of plotting the cross sections begins. Teach the students how to interpret the notes. For instance a section

| Left. | | C. L. | | Right. |
|---|---|---|---|---|
| 100′ | 15′ | 3+00 | 50′ | 100′ |
| 316 | 315 | 314.3 | 314 | 313.05 |

would mean that the elevation on center line at station 3+00 was 314.3 feet above sea level; fifty feet to the right it was 314 above, etc.

Then it becomes necessary to select a scale for the cross sections. A scale of one centimeter to fifty feet will be convenient. The vertical scale should be exaggerated in order to facilitate reading the contour notes. A vertical scale of one centimeter to one foot is advisable. Then, starting in the upper left-hand corner, each section should be plotted on the graph paper. Here are a few sections for illustration. Using the scales suggested above, it will be seen that the ground is level to the left of the center line at 0+00 but that ninety feet to the right there is a drop of half a foot, while one hundred feet to the right we have a drop of one and four-fifths feet. The plotting of these cross sections will take the remainder of this period and may be finished at home.

The third day, the work will be to figure or read the contour notes from the cross sections. A convenient contour interval on fairly level ground will be a half foot. Then, by looking at the level notes, find the point of lowest elevation and make the first contour line the even foot or half foot nearest this point.

Then examine the sections immediately preceding and succeeding this one to see if a point of equal elevation can be found. If not, take the next contour line and find points of that elevation on that section, seeing if such a point can be found on the adjoining sections. Proceed in this manner, advancing one contour at a time, and recording for each contour the stations at which it is possible to get such an elevation, and also the distance from center line to such a point. This distance can be read directly from the plot of the section.

To illustrate, in the sections given, the point of lowest elevation is 309.9 at section 3+00. So we will start with the 310th contour. At section 3+00, this will be but one hundred feet to the right. Examining sections 2+50 and 3+50, we find no such elevation. Taking the next contour 310.5, we find that at section 2+50 we can find the proper elevation 98′ to the right. At 3+00 it is 95′ to the right. At 3+50 we cannot get it, but at 4+00 it is 80′ to the right. These notes should be written thus:

Contour 310—3+00—100′R.
Contour 310.5—2+50—98′R, 2+00—95′R.
4—00+8.0′ R.
Contour 311.
Contour 311.5—etc.

These notes should be made for every contour obtainable.

Plotting the points represented by the contour notes is the work of the next day. The stations of the center line are indicated by the notes. The student must simply take one contour at a time, and moving from station to station, plot all the points in the notes for that one contour. Then a light, regularly curving line should be drawn, connecting these points and the contour, labeled with the elevation.

After this exercise, the students will not look upon map work as something beyond their comprehension, nor regard the United States topographic sheets as masses of "crooked brown lines." And the three great benefits of the study of such maps—to illustrate by example different kinds of topography, teaching topography first-hand, and appreciation of the topographic atlas—will be much more fully derived by each member of the class. A more advantageous laboratory exercise could not be given.

Should any teacher care to carry out the plans outlined above, I would be glad to cooperate with him and give detailed explanations of any phase of the work.

## PROBLEM DEPARTMENT.

BY J. O. HASSLER,
*Englewood High School, Chicago.*

*Readers of this magazine are invited to propose problems and send solutions of problems in which they are interested. Problems and solutions will be credited to their authors. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

### Algebra.

466. *Proposed by F. M. Phillips, Pella, Iowa.*

Solve for integral values of $x$, $y$, and $z$.

$$x+y^3+z^3 = 2, \tag{1}$$
$$x^3-y^3+z^3 = 4, \tag{2}$$
$$x^3-5xy^3+z^3 = 8. \tag{3}$$

I. *Solution by Mabel G. Burdick, Stapleton, N. Y.*

Eliminating $z^3$ from the equations, then $x$ and $y^3$, we have

$$f(x) = x^3-x^2-5xy^3+y^3-4 = 0$$

of which possible integral solutions must be factors of $y^3-4$, i. e., $\pm 1$, $\pm(y\pm 2)$, or $\pm(y^3-4)$. The only solutions are

$$f(-1) = 6y^3-6 = 0 \quad \text{if } y = \pm 1,$$
$$f(-y+2) = 4y^3-6y^2-8y = 0 \quad \text{if } y = 0.$$

The values are

$$x = 2, \ -1, \ -1,$$
$$y = 0, \ -1, \ -1,$$
$$z = 0, \ +2, \ -2.$$

II. *Solution by R. W. Lord, Plainfield, New Jersey.*

Eliminating $z^3$ from (1) and (2) gives

$$x^3-x-(y^3+y^3+2) = 0. \tag{4}$$

Eliminating $z^3$ from (1) and (3) gives

$$x^3-(5y^3+1)x-(y^3+6) = 0. \tag{5}$$

Let

$$a = -(y^3+y^3+2), \quad b = -(5y^3+1), \quad c = -(y^3+6). \tag{6}$$

The eliminant of (4) and (5) is found by multiplying (4) by $x$ and $x^2$ and (5) by $x$ which with the equations (4) and (5) gives one more equation than there are powers of $x$. These equations are, after substituting $a$, $b$ and $c$ for purposes of simplifying,

$$\begin{aligned} x^2- x+a &= 0, \\ x^3 \quad +bx+c &= 0, \\ x^3-x^2+ax \quad &= 0, \\ x^4-x^3+ax^2 \quad &= 0, \\ x^4 \quad +bx^2+cx \quad &= 0. \end{aligned}$$

In order that there may be a solution of these five equations, the determinant

$$\begin{vmatrix} 0, & 0, & 1, & -1, & a \\ 0, & 1, & 0, & b, & c \\ 0, & 1, & -1, & a, & 0 \\ 1, & -1, & a, & 0, & 0 \\ 1, & 0, & b, & c, & 0 \end{vmatrix} = 0.$$

The evaluation of this determinant gives

$$(a-c)^2+\{(a-b-1)[(a-c)-a(b-a+1)]\} = 0,$$

Substituting the values of $a$, $b$ and $c$ from (6) in this expression, we have

$$y^9-7y^8+8y^7+22y^6-29y^5+19y^4+16y^3-38y^2 = 0,$$

a single equation in $y$ which has 0 and $-1$ as the only integral roots.

Substituting these values of $y$ in (4),

$$y = 0, \quad 0, -1, -1,$$
$$x = 2, -1, \quad 2, -1.$$

Substituting these values of $x$ and $y$ in equation (1),

$$x = 2, -1, \quad 2, -1,$$
$$y = 0, \quad 0, -1, -1,$$
$$z = 0, \sqrt{3}, \pm 1, \pm 2.$$

Of these values the second does not give integral values for $z$ and the third does not satisfy (3). Therefore, we have as the only integral values, (2, 0, 0) and $(-1, -1, \pm 2)$.

467. *Proposed by F. L. Sanders, Connersville, Ind.*

The area of a triangle whose sides are 3, 4 and 5 is 6, and if the sides are 13, 14 and 15, the area is 84. Will someone find the next set, or general solution for such sets, of three consecutive integers which as the measures of the sides of a triangle give rise to an integral area?

[The editor was quite surprised at the interesting results discovered by the contributors in this problem. Attention is called to the first solution below because it illustrates how simple a solution may be made if one chooses properly among the resources at his command in mathematics. The solutions of Norman Anning and Nelson L. Roray were practically the same as solution I, being based on Pell's equation. The second solution is a good type of more than half those sent in. The third represents a different angle of investigation entirely.—Editor].

I. *Solution by George Y. Sosnow, Newark, N. J.*

Represent the sides by $2k-1$, $2k$ and $2k+1$. The area of the triangle, by Hero's formula, is $k\sqrt{3(k^2-1)}$. Since the area must be a rational integer, $3(k^2-1)$ must be a perfect square, or

$$k^2-1 = 3L^2, \quad \text{whence } k = \sqrt{3L^2+1}. \qquad (1)$$

Now $k^2-3L^2 = 1$ is a particular example of the so-called "Pellian Equation." The general solution, as given in Chrystal's text, Part II. page 452, shows that

$$L = \frac{1}{2\sqrt{3}}\left[(2+\sqrt{3})^n-(2-\sqrt{3})^n\right].$$

This value of L gives for the sides, according to (1), $[2+\sqrt{3})^n+(2-\sqrt{3})^n]$, the same plus unity, and the same minus unity. There are an infinite number of solutions, since $n$ may be any number greater than zero.

II. *Solution by Murray J. Leventhal, Stuyvesant High School, New York City.*

Let $2n$, $2n+1$, $2n+2$ be the sides of a triangle. Substituting for $a$, $b$, $c$, $s$ in the formula

$$A = \sqrt{s(s-a)\ (s-b)\ (s-c)} \qquad (1)$$

and simplifying, we get

$$A = \frac{2n+1}{4}\sqrt{3(2n-1)\ (2n+3)}.$$

Since the product and square root of the product of odd numbers is odd, A can not be integral. Therefore, the smallest side of such a set of consecutive integers can not be even.

Let $2n+1$, $2n+2$, $2n+3$ be the sides. Substituting in (1) and simplifying,

$$A = (n+1)\sqrt{3n(n+2)}.$$

A is integral when

$$3n(n+2) = a^2, \qquad (2)$$

$a$ being any integer. From (2)

$$n = \tfrac{1}{3}\sqrt{3a^2+9} - 1.$$

Choose $a$ so that $3a^2+9$ is a perfect square, making $n$ and, consequently, A integral. In finding $a$ only multiples of 3 need be considered, since $a^2$ must be divisible by 3. $n = 1$, $n = 6$ give 3, 4, 5 and 13, 14, 15—two familiar sets. When $a = 45$, $n = 25$ and the sides are 51, 52, 53; $a = 168$, $n = 96$ and we have 193, 194, 195. Multiples of 3 that make $3a^2+9$ a perfect square may be found ad infinitum. To get the area, multiply $n+1$, by $a$.

III. *Solution by Artemas Martin, LL.D., Washington, D. C.*

Let $2x-1$, $2x$, $2x+1$ denote the sides of a rational triangle whose sides are consecutive whole numbers. The area of such a triangle will be

$$\sqrt{3x^2(x-1)(x+1)} = \sqrt{3(x^2-1)}.$$

Now put

$$3(x^2-1) = \square = 9y^2$$

and, after solving for $x$, we obtain

$$x = \sqrt{3y^2+1}. \qquad (1)$$

The least value of $y$ satisfying (1) is 0, which gives $x = 1$; but this value of $x$ does not produce a triangle.

The next value of $y$ satisfying (1) is $y_1 = 1$, which gives $x_1 = 2$, and the sides of the first or *least* triangle are 3, 4, 5.

The third value of $y$ is $y_2 = 4$, which gives $x_2 = 7$, and the sides of the second triangle are 13, 14, 15.

The fourth value of $y$ is $y_3 = 16$, which gives $x_3 = 26$, and the sides of the third triangle are 51, 52, 53; and so on.

The successive values of $x$ are easily seen to be connected by the relation

$$x_n = 4x_{n-1} - x_{n-2} \qquad (2)$$

and the sides of the $n$-th triangle are $2x_n-1$, $2x_n$, $2x_n+1$, where $x_n$ is defined by (2).

From these expressions we find

| | | | |
|---|---|---|---|
| 4th, | 193, | 194, | 195. |
| 5th, | 723, | 724, | 725. |
| 6th, | 2701, | 2702, | 2703. |
| 7th, | 10083, | 10084, | 10085. |
| 8th, | 37633, | 37634, | 37635. |
| 9th, | 140451, | 140452, | 140453. |
| 10th, | 524173, | 524174, | 524175. |
| 20th, | 274758382273, | 274758382274, | 274758382275. |
| 30th, | 144021200269567501, | 144021200269567502, | 144021200269567503. |

Any reader who cares to do so can verify these—or disprove them.

IIIB. *Further results and remarks by F. M. Phillips, Pella, Iowa.*

[Mr. Phillips discovered the same formula as given by Dr. Martin and adds the following results.—Editor.]

Let $y$ be the area of the $n$-th triangle. Then

$$y_n = 14y_{n-1} - y_{n-2}.$$

The areas of the first nine triangles are: 6, 84, 1170, 16296, 226974, 3161340, 44031786, 613283664, 8541939510.

*Note the repetition of certain figures in the last digits of the numbers of the series for areas and sides, e.g., 6,4,0,6,4,0,. . ,.*

## Geometry.

468. *Proposed by F. M. Phillips, Pella, Iowa.*

Find the locus of the center of all circles, (a) tangent to a given line and a given circle, (b) tangent to two given circles.

I. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let MN (Fig. 1) be the given straight and O the given circle. Take OP⊥MN and produce to P′ making PP′ = OL, also take P′M′⊥OP′. Take any diameter AB of the circle. Draw the tangents at A and B intersecting MN at Q and M respectively. Bisect ∠AQN with $QO_2$ intersecting AB at $O_2$; bisect ∠BMN with $MO_1$ intersecting AB at $O_1$. Evidently $O_2$ and $O_1$ are centers of circles tangent to the given circle and the given straight.

Now $OO_2$ equals the perpendicular from $O_2$ to P′M′.

*Therefore the locus of* $O_2$ *is a parabola with focus at* O *and* P′M′ *its directrix.*

Take PP″ = OL so that P lies between P′ and P″ also P″M″⊥OP.

Now $OO_1$ equals the perpendicular from $O_1$ to P″M″.

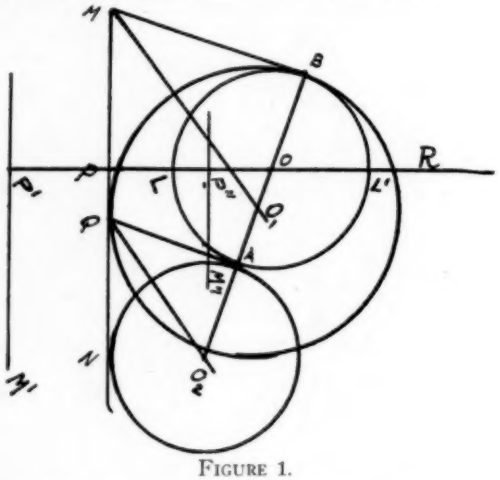



FIGURE 1.

*Therefore the locus of* $O_1$ *is a parabola with focus at* O *and* P″M″ *its directrix.*

The circles that are tangent to O at B enclose O; those tangent to O at A never enclose O. When A is at L′ $O_2$ is at infinity, likewise $O_1$ and the circles are tangent to MN at infinity.

If MN is tangent to O at L all the circles at B coincide with O except when B is at L. At this point there are an infinite number of circles tangent to O and MN, the locus of whose centers is the straight LO, that is the parabola has become a straight. Also the point of tangency at infinity has become the point L. The parabola $O_2$ has L for its vertex.

*When* MN *intersects* O *in two distinct points* parabola $O_1$ has its vertex on sect OL′ instead of OL but retains O for its focus. Neither the B circles nor the A circles enclose O, but part of each lie within O and part without. *The two parabolas, straight* MN *and* O, *intersect in common points, that is, where the straight intersects the circle.*

Let $O_1$ & $O_2$ (Fig. 2.) be the given circles. The circle tangent to the given circles is constructed by finding P, the point where the common tangent intersects the straight $O_1O_2$, and then drawing a secant PRSS′R′; where O′S intersects $O_2S'$ is the center of the given circle. Evidently $O_1R$ and $O_2R'$ give a second circle. By taking the common internal tangent we get two more. Hence there are four circles tangent to two given circles.

Let $O_1S = r$, $O_2S' = R$ and $SO_3 = \rho$.

Then $|O_1O_3 - O_2O_3| = |R+\rho-r-\rho| = |R-r|$.

*Therefore the locus of* $O_3$ *is a hyperbola whose foci are* $O_1$ *and* $O_2$.

If $O_1O_2 = D$ and K the origin is midpoint of $O_1O_2$, the equation of the hyperbola of the external tangent is readily shown to be

$$\frac{x^2}{\frac{(R-r)^2}{4}} - \frac{y^2}{\frac{D^2-(R-r)^2}{4}} = 1.$$

If $R = r$, then $x^2 = 0$, 2 *coincident straights bisecting* $O_1O_2$ *at right angles.*

If $D = |R-r|$ then $y^2 = 0$, 2 *coincident straights coinciding with* $O_1O_2$.

If $D < R-r$, then we have *an ellipse.*

If $D = 0$ then $x^2+y^2 = \frac{(R-r)^2}{4}$ *a circle.*

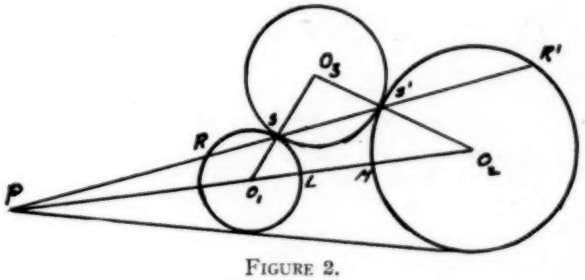



FIGURE 2.

Let $LM = 2a$ and transfer origin to midpoint of LM then the equation becomes $(R-r)^2y^2-4(r+a)(R+a)[x^2+x(R-r)-(r+a)^2] = 0$.

If R becomes infinite we have the condition required in (a), that is a straight and a circle.

If $R = \infty$ then

$$(R-r)^2y^2-4(r+a)(R+a)[x^2+x(R-r)-(r+a)^2] = 0.$$

becomes $y^2 = 4(r+a)x$,

the equation of the parabola for $O_2$ in part (a).

If $r$ is also infinite, we have

$$x = 0.$$

the equation of the locus of the center of a circle tangent to two given parallels.

The equation for the hyperbola of the internal tangent is

$$\frac{x^2}{\frac{(R+r)^2}{4}} - \frac{y^2}{\frac{D^2-(R+r)^2}{4}} = 1.$$

If $R = r$ we still have a hyperbola.

If $D = (R+r)$ then $y^2 = 0$, as above.

If $D < (R+r)$ we then have an ellipse.

If $D = 0$ then $x^2+y^2 = \frac{(R+r)^2}{4}$ a circle.

When R becomes infinite we have condition for $O_1$ parabola in part (a).

469. *Proposed by Clifford N. Mills, Brookings, S. D.*

In a triangle $A_1B_1C_1$, a circle is inscribed, touching the sides in $A_2B_2C_2$. A circle is inscribed in the triangle $A_2B_2C_2$, touching the sides of $A_2B_2C_2$ in $A_3B_3C_3$. This process is continued an infinite number of times. Show

that $A\infty = B\infty = C\infty = \frac{\pi}{3}$.

I. *Solution by Mabel G. Burdick, Stapleton, N. Y.*

If R represents the radius of the circumscribed circle of any triangle, and $r$ the radius of the inscribed circle, and $\delta$ the distance between their centers,

$\delta^2 = R^2 - 2Rr$. (already proved in this department)

As this process is continued an infinite number of times, $R^2 - 2Rr = 0$, and $\therefore \delta^2 = 0$, or the triangle approaches an equilateral triangle as a limit.

$$\therefore A\infty = B\infty = C\infty = \frac{\pi}{3}.$$

II. *Solution by Norman Anning, Chilliwack, B. C.*

From a figure it is readily shown that

$$2A_2 = B_1 + C_1,$$
$$2B_2 = C_1 + A_1,$$
$$2C_2 = A_1 + B_1.$$

Let triangle $A_1B_1C_1$ have the angles, $60° + x$, $60° + y$, $60° - (x+y)$.

Then triangle $A_2B_2C_2$ will have the angles, $60° - \frac{x}{2}$, $60° - \frac{y}{2}$, $60° + \frac{x+y}{2}$,

Triangle $A_3B_3C_3$ will have the angles, $60° + \frac{x}{4}$, $60° + \frac{y}{4}$, $60° - \frac{x+y}{4}$,

Triangle $A_4B_4C_4$ will have the angles, $60° - \frac{x}{8}$, $60° - \frac{y}{8}$, $60° + \frac{x+y}{8}$, etc.,

It will be observed that each angle is nearer to 60° than is the angle standing just above it, provided that none of the quantities, $x$, $y$, and $x+y$, is zero. If any one of these is zero the corresponding angle remains equal to zero from first to last. Since, as $n$ increases, $\frac{x}{2^n}$, $\frac{y}{2^n}$ and $\frac{x+y}{2^n}$ approach zero as a limit, we can, by continuing the above process, arrive at a triangle as nearly equiangular as desired. Stated briefly, $A\infty = B\infty = C\infty = \frac{\pi}{3}$.

III. *Solution by Nelson L. Roray, Metuchen, New Jersey.*

Evidently $A_1 = \frac{180 - A}{2}$, $A_2 = \frac{180 - A_1}{2}$, $A_3 = \frac{180 - A_2}{2}$, etc.

Also $A_2 = \frac{(2-1)\ 180 + A}{2^2}$

$$A_3 = \frac{(2^2 - 2 + 1)180 - A}{2^2}$$

$$A_4 = \frac{(2^3 - 2^2 + 2 - 1)180 + A}{2^4}$$

$$A_n = \frac{(2^{n-1} - 2^{n-2} + 2^{n-3} + (-1)^{n-1})180 + (-1)^n A}{2^n}$$

$$= \left(\frac{1}{2} - \frac{1}{4} + \frac{1}{8} - \frac{1}{16} + \cdots\right)\pi + \frac{(-1)^n A}{2^n}$$

$$A_n \doteq \infty \doteq \frac{\pi}{3}.$$

Similarly for angles B and C.

470. *Proposed by the Editor.*

One of the eleven solutions printed in this department this month (June) is not correct. Find it and point out the error.

No solution has been received for this. The fallacious solution is the third one of 454 on page 261, published under the fictitious name of H. O. Jay. The solution was sent in by two different contributors. Since it is not always possible to construct a triangle with the altitudes of another triangle the method of construction as given there is not good for all cases. Indeed it could only be applied in approximately half the cases that might arise.—Editor.

## CORRECTION.

There are three misprints in the solutions of 456 in the April issue, namely: In the first solution, by Norman Anning, $S_n$ should be $2^{n-1}-\frac{1}{2}$ and the final result should be

$$\frac{1}{1-x} - \frac{2^n x^{2^n-1}}{1-x^{2^n}}$$

The final result in the second solution has the same error.

## CREDIT FOR SOLUTIONS.

461. Aaron Freilich, one incomplete solution. (2)

466. Mary E. Caster, Mabel G. Burdick, F. M. Phillips, R. W. Lord, one incomplete solution. (5)

467. Mabel G. Burdick, Nelson L. Roray, Frederick H. Hodges, Geo. Y. Sosnow, Frank C. Gegenheimer, F. M. Phillips, Artemas Martin, Murray J. Leventhal, R. T. McGregor, Elmer L. Hunting, Norman Anning, Katherine S. Arnold, Mary E. Caster, Myra J. Hawes. (14)

468. Nelson L. Roray, Frank C. Gegenheimer, Mabel G. Burdick, F. M. Phillips, Mary E. Caster, M. Helen Kelly. (6)

469. Norman Anning, Nelson L. Roray, Mabel G. Burdick. (3)

Total number of solutions, 30.

## PROBLEMS FOR SOLUTION.

### Algebra.

481. *Proposed by Paul Baldwin, Evansville, Ind.*

Find the roots of the equation,

$$x^4-(x^3-1)\sqrt{x^3+44}+22x^2-x-14 = 0.$$

### Geometry.

482. *Proposed by R. S. Beardsley, Chicago, Ill.*

Prove that the dihedral angle of a regular tetrahedron is the supplement of the dihedral angle of a regular octahedron.

483. *Proposed by the Editor.*

The following method of inscribing a regular polygon of any number of sides in a given circle is described (without proof or acknowledgment of approximation) in a certain correspondence school text book on geometrical drawing:

"Given a circle with center O and diameter AC. With A and C as centers and AC as a radius describe short arcs intersecting at M and draw MO intersecting the circle beyond O at N. Divide AO into as many equal parts as the polygon has sides and make OD equal to 4 of these parts. Draw MD intersecting the circle beyond D at E. NE is a side of the desired polygon. For polygons with less than 10 sides use twice the number of sides."

(a) Prove this construction correct or incorrect as applied to the dodecagon.

(b) Find a general formula that will show the error of construction for any number of sides.

### Trigonometry.

484. *Proposed by W. L. Baughman, East St. Louis (Ill.) High School.* Show that

$$\tan 18^\circ = \frac{(3\sqrt{5}-5)(\sqrt{10+2\sqrt{5}})}{20}$$

485. *Proposed by Nelson L. Roray, Metuchen, N. J.*

If $\cos\theta+\cos\phi = a$, and $\sin\theta+\sin\phi = b$, find $\cos\theta\cos\phi$.

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## SCIENCE HELPS.

Science teachers welcome different ways of doing the same experiment for succeeding classes. Eight or ten years ago the writer described at the meeting of the Michigan School Masters' Club, a simple way of germinating seeds with, and without, air, especially in schools where the more elaborate apparatus is not at hand.

Half of a lot of peas that have been soaked for about eight hours are placed in some ordinary gelatin about the consistency of common fruit jelly. It is important not to soak the seeds too long, as otherwise they will absorb oxygen enough to germinate for a time, even after the air is shut off. The gelatin is to be warmed just enough so that the seeds will sink under the surface about twice the diameter of the seeds.

That the seeds are not killed, and will germinate in the air may be shown if the seeds are removed from the gelatin just as soon as the control lot in the air has germinated; say, in two days. Even in three days the seeds in the gelatin will germinate, but after that time success is only occasional. L. M.

To Burn a Steel Wire (Picture Wire) in Oxygen.

A simpler way than the ordinary is to tie a bit of wood in the end of the wire by a turn or two of the wire, and ignite this and then thrust it into the oxygen. L. M.

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## A NEW FLY TRAP.

The English sparrow (*Passer domesticus*) is by far the most abundant bird in the cities of Imperial Valley, outnumbering all other birds (in the city districts) about ten to one. I have noticed them on several occasions congregated around store fronts early in the mornings while the air was still very cold. Close observation showed that the birds were industriously making hearty breakfasts of the flies which had settled on the store fronts the warm evening before, and were now benumbed with the cold. The supply of flies seemed inexhaustible, but these imported fly traps must have eaten enormous quantities. I have seen the flies so thick that they could be brushed up by the quart. If the supply of English sparrows in Imperial Valley can be increased sufficiently, the fly question in that section ought to be solved, for flies, like English sparrows, seem to thrive around our smaller cities and towns.—*The Condor.*

## SCIENCE QUESTIONS.

By Franklin T. Jones,
*University School, Cleveland, Ohio.*

*Readers of* School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

### Questions and Problems for Solution.

227. What do the readers of School Science and Mathematics wish to see discussed in the *Science Questions* department?

Is the material at present published (1) interesting, (2) instructive, (3) helpful, (4) stimulating? If not, why? How can we know whether it is right unless we hear directly from you? Nothing is more useful than constructive criticism.

Report your experiences and investigations.

Help the Editor of this department by sending to him copies of your June examinations in chemistry, physics, botany, zoology, physical geography and especially general science.

228. *Proposed by W. L. Baughman, East St. Louis, Ill.*

A rod whose center of gravity divides it into two parts, $a$ and $b$, is placed inside a smooth sphere of such a radius that the rod subtends an angle of $2k$ at the center. Find the inclination of the rod to the horizon.

229. *Proposed by O. L. Brauer, Selma, Cal.*

*Question.* If you look at a distant light through a wire window screen, you see a symmetrial cross of light radiating from the source. If you look through the screen at an acute angle, there appears an unsymmetrical star of six points. These lines of light are about twenty times as long as the diameter of the light. (The screen is made of about No. 22 iron wire, making little squares about 2 mm. on a side.) How is this phenomenon explained?

230. *Proposed by Milton Gallup, student in University School, Cleveland.*

Why does it squeak? Some sulphur was melted and burning in a deflagration spoon. It was poured from the spoon and allowed to fall through the air from a second story window. As it neared the ground, a note of high pitch was emitted which has been described as a squeak. Try the experiment and send in your explanation.

### Solutions and Answers.

198. *From Mann & Twiss' Physics, sent in by John C. Parkard, Brookline, Mass.*

A fast skater collides with a slow one. Who gets the worse bump?

*Answer by C. M. Turton, Chicago, Ill.*

Theoretically, the fast skater should get the worse bump, but in practice I doubt it. The slow one will be knocked down as I was many times when I was a boy.

*Answer by George R. Twiss. (This answer because of its length, is published in part only.)*

This question is a sample of many which are of such a nature that they almost invariably start a discussion in a class, and are profitable for that reason, if rightly used. The first thing that ought to come out of the discussion is that we cannot arrive at an agreement unless we first define conditions and terms—a very important thing for young people to

learn. The question leaves the determination of conditions to the class, which is a good thing to do occasionally in order that they may have practice in doing this.

The simplest assumptions that we may make and agree on are that the boys have equal masses and are equally tough. In this case, neither will get the worse bump; for the force developed by the collision acts equally on both and in opposite directions.

200. *Note concerning this question by R. W. Tarbell, Central Continuation School, Milwaukee, Wis.*

Mr. J. J. Metz, instructor in the apprentice department here, has given me the following note concerning your March number, which I submit as follows:

"On page 265, of your March issue, A. H. Smith submits a solution for Problem 200 which I believe is incorrect. He evidently neglected to change the 60-pound gage water pressure to absolute pressure. This is necessary when applying Boyle's Law. This correction has been made in the following solution:

$75 : 15 :: x : 1.$

$x$ equals 5, increase in pressure.

$\frac{1}{5}$ of 50 equals 10 gals., vol. of air.

50—10 equals 40 gals., vol. of water.

211. *From a Princeton Physics Paper.*

A piece of platinum weighs 71.2 grams when submerged in mercury—what is the volume of the platinum? What would it weigh if it were submerged in alcohol?

Sp. Gr. of platinum = 21.5, of mercury = 13.6 and of alcohol = 0.8.

*Solution by Ernest A. Bixby, Stevens High School, Claremont, N. H.*

*Also solved by J. P. Drake (Ans. 186.5 gm.), R. E. English, Carlton Pardee (Ans. 187.542 gm.).*

Each cc. of platinum when submerged in mercury loses 13.6 gm. in weight as that is the weight of 1 cc. of mercury. As each cc. of platinum weighs 21.5 gm. in air, 21.5—13.6 or 7.9 gm. is the weight of 1 cc. in mercury. $\frac{71.2}{7.9}$ or 9.01 cc. is the volume of the platinum. 21.5—.8 = 20.7 gm. weight 1 cc. in alcohol.

$20.7 \times 9.01 = 186.5$ gm. *Ans.*

*Solution by R. E. English.*

21.5 g.—13.6 g. = 7.9 g. wt. of a cc. of platinum when submerged in mercury.

$71.2 \div 7.9 = 9.013$ cc. volume of platinum.

21.5—.8 = 20.7 g. wt. of a cc. of platinum when submerged in mercury.

$20.7 \times 9.013 = 186.57$— g. wt. of platinum in alcohol.

212. *From a Princeton Physics Paper.*

A hot-air balloon, when inflated with air at 40° C. above the temperature of the surrounding air, displaces 1 cubic meter. The density of air at the ordinary temperature is 0.0012 grams per cu. cm., and the coefficient of expansion = 0.0037. Calculate the total lifting power due to the heated air.

*Solution by J. P. Drake, State Normal School, Emporia, Kans.*

*Also solved by R. E. English.*

The increase in vol. per cc. for 40° rise in temperature is $.0037 \times 40 = .0148$. Since the density is inversely proportional to the volume the decrease in density for the same change in temperature will be $.0012 \times .0148 = .00001786$.

The difference in wt. per cu. meter then will be 1,000,000 times .00001786 = 17.86 grams = lifting force.

213. *Proposed by E. V. Hjort, Mason City, Iowa.*

One of the farmer girls in the high school states that in her section of the county it is a general impression among the farmers that a tile drain drains the land better than an open ditch.

Is this so, and if it is so, why is it?

*Note by the Editor.*

The tile drain is better than the open ditch: (1) The tile lies lower than the bottom of the ditch; (2) when water stands in the ditch or is flowing in it, the ground is saturated up to the water level. On the contrary, the tile drain keeps the point of saturation lower in the ground and withdraw the water before it reaches the ditch level. To pack earth in a sewer excavation, water is used. When ground is saturated with water, the earth packs in the same way, thus losing the ability to hold air, and to prevent too rapid evaporation of moisture in dry weather. It is a well-known fact that a loose top layer of earth is necessary to prevent a field from drying out in hot weather.

214. *Proposed by Ross Grange, Sioux City, Iowa.*

The chemistry examination following was given to cover the first semester's work in high school chemistry given in Sioux City High School. I should suggest that it be printed in *Science Questions* of SCHOOL SCIENCE AND MATHEMATICS.

If possible, I should like to have it discussed—(a) as to whether or not it covers the ground sufficiently; (b) is it too long for a two-hour examination; (c) is it too difficult; and (d) does it give enough importance to applied topics?

*Note by Editor.*

The fact that no adverse comment has come to the Editor's desk indicates that this examination paper was satisfactory to readers of SCHOOL SCIENCE.

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## CORRELATION OF THE MECHANICAL AND MAGNETIC PROPERTIES OF STEEL.

A review of the work done in correlating the magnetic and mechanical properties of steel has just been published by the Bureau of Standards, Department of Commerce, in its Scientific Paper, No. 272. Special attention is paid to the commercial application of the magnetic data as criteria of the mechanical fitness of a given steel and of magnetic changes of steel under stress as indications of the state of strain. The evidence presented shows that the interrelation of the magnetic characteristics and the mechanical behavior of steel is so close that the magnetic examination in conjunction with the mechanical tests may be expected to add considerably to our knowledge of the material.

The magnetic method tests the whole amount of material and not merely some surface phenomenon. It does not destroy the test piece, but leaves it unaltered. Thus, it is possible to apply a magnetic test to the identical material that is to enter into a given structure.

Copies of the publication, the title of which is *Correlation of the Mechanical and Magnetic Properties of Steel*, will be sent free upon request to the Bureau of Standards, Washington, D. C.

## ARTICLES IN CURRENT PERIODICALS.

*American Journal of Botany*, for March; *Brooklyn Botanic Garden; $4.00 per year, 50 cents a copy, plus postage:* "The Specificity of Proteins and Carbohydrates in Relation to Genera, Species and Varieties," Edward Tyson Reichert; "Mechanics of Dormancy in Plants," William Crocker; "The Periodicity of Freshwater Algæ," Edgar Nelson Transeau.

*American Mathematical Monthly* for March; *5548 Kenwood Ave., Chicago, Ill.; $3.00 per year:* "Constitution of an Algebraic Equation with an Irrational Root," L. S. Dederick; "Napier's Logarithmic Concept: A Reply," Florian Cajori; "A Note on the Calculation of Euler's Constant," Goldie Horton; "The Retirement of Sir Thomas Muir," C. T. Loram; Problems and Solutions; Questions and Discussions.

*Condor*, for March-April; *Los Angeles, Cal.; $1.50 per year, 30 cents a copy:* "Sea Gulls at the Panama-Pacific International Exposition" (with twenty-one photos by the author), Joseph Mailliard; "Characteristic Birds of the Dakota Prairies IV. On the Lakes," Florence M. Bailey; "The Farallon Rails of San Diego County" (with four photos by Donald R. Dickey and the author), Laurence M. Huey; "The Nutcrackers of Yellowstone Park," M. P. Skinner; "A Chapter in the Life History of the Wren-tit" (with two photos by Tracy I. Storer), Walter C. Newberry; "The New Museum of Comparative Oology." William L. Dawson; "Notes on Some Land Birds of Tillamook County, Oregon," Stanley G. Jewett.

*Journal of Educational Psychology* for March; *Warwick and York, Baltimore, Md.; $2.50 per year, 30 cents a copy:* "Some Norms of Dartmouth Freshmen," W. V. Bingham; "A Point Scale for the Mental Measurement of the Blind," Thomas H. Haines; "Distribution of Practice Periods in Learning," Herbert Hayes Murphy.

*Journal of Geography* for April; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Some Problems in Geographic Education with Special Reference to Secondary Schools," R. E. Dodge; "Economic Geography: Its Growth and Possibilities," R. H. Whitbeck; "Geography in the Junior High School," Clara B. Kirchwey; "Lost Opportunities in Teaching Geography," Zonia Baber; "An Examination in Elementary Geography," Lawrence Martin.

*Nature Study Review for April; Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "Taking Nature Study to the Teacher," Charles W. Finley; "The Great Chip Rocks of the Hudson," G. T. K. Norton; "Home Museum," B. Clifford Hendricks; "The Burroughs Nature Club," Ellen M. Phillips; "An Outline for Bird Study," Bessie M. Hayden; "Wild Flowers at Home," R. W. Shufeldt; "Nature Photography," Earl D. Huntington; "School Gardening a Fundamental Factor," Leroy H. Harvey.

*Photo-Era* for April; *383 Boylston St., Boston; $1.50 per year, 15 cents a copy:* "Stereo-Photography," L. A. Gareis; "How to Improve One's Negatives," Albert J. Treichler; "The Autochrome in Bird-Photography," Dr. Frank Penrose; "Outdoors with the Kiddies," Charles J. Adams; "With a Camera in Insect-Land," Lehman Wendell; "Duplicating Negatives," Rev. A. E. Murray; "A Sunlight Enlarging-Device," E. L. Austen.

*School World* for April; *Macmillan & Company, St. Martin St., London, W. C.; 7 s. 6 d. per year:* "A School Lantern-Slide Collection," Geo. H. Rydall; "School Instruction in Science for Military Purposes," C. L. Bryant; "The Employment of School Children in Agriculture;" "The Teaching of Geography in American Schools;" "Retrenchment in Public Expenditure on Education;" "Toymaking," Ruby K. Polkinghorne.

*Scientific Monthly* for April; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* "Problems Associated with the Study of Coral Reefs," W. M. Davis; "The Exudation of Ice from Stems of Plants," Dr. W. W. Coblentz; "Java, the Exploited Island," Dr. Alfred G. Mayer; "National Defense Development: National Defense and Efficiency," S. Stanwood Menken; "The Wisdom and Ethics of Preparedness," Henry A. W. Wood; "The Logic of Physical and Mental Preparedness," Newell B. Woodworth; "National Defense and Education," Henry H. Ward; "The Economic and Strategic Value of the Lincoln Highway," Austin F. Bement;

"Agricultural Efficiency, a Foundation for National Defense," Howard H. Gross; "Peace through National Defense," Anne R. Minor; "Immunity of Monuments in War and Peace," George F. Kunz; "Preparedness—Some Suggestions," Arthur Williams; "Preparedness," John Q. Tilson; "American Extravagance, a National Problem," E. A. Woods.

*Zeitschrift für dem Physikalischen und Chemischen Unterricht,* for January; *Berlin, verlag von Julius Springer; M. 12:* "Uber den Gebrauch Braunschen Röhre zur Analyse von elektrischen Schwingungen im Unterricht," F. Hochheim; "Ein einfacher Apparat für Schülerübungen aus der Optik und Wärmelehre," P. Hanck; "Neue Wellenmaschinen," F. Fricke; "Einfache Demonstrationsversuche mit Wechselstrom," B. Reismann; "Elementare Ableitung der Wegformel des freien Falles." H. Greinacher; "Die Regentropfen am Wagenfenster," A. Lanner; "Schülerversuche mit Schallresonanzröhren," H. Lohmann.

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An interesting order was received recently by a Chicago firm for shipment to South Africa. It consisted of a cargo of creosoted oak ties for use in building a new railroad. For many years it has been necessary to use metal ties in parts of South Africa on account of the ravages of the white ants. It now seems to be conclusively demonstrated that creosote treatment is an effective protection against these insects. Even with this fact established, an order for creosoted ties would hardly be expected in America, and the explanation is that the war has closed the Baltic ports and Europe is now unable to supply creosoted timbers in the African market. Within the past year, several cargoes of creosoted Douglas fir ties have been shipped from Pacific Coast points for use in India, and since the average life of a well-creosoted tie, properly protected from mechanical wear, is about thirty years, it is a natural expectation that a further export market for creosoted American timbers will be found.—*American Forestry.*

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## FROM FIELD AND STUDY.

### A Note on the Food of the Western Robin.

By Aretas A. Saunders,

*New Haven, Connecticut.*

In front of the Biological Station building at Flathead Lake, Montana, a small spring seeps into the lake, making a damp spot in the sand of the lake shore. Here, in the month of July, swarms of butterflies congregate to drink. The butterflies are principally of two species, *Papilio rutulus,* a large yellow and black one, and *Papilio eurymedon,* an equally large one in cream color and black. These butterflies became so absorbed in their drinking that they could be easily approached and sometimes picked up in the fingers. One day, I was much amused to notice that a robin (*Planesticus migratorius propinquus*) took advantage of this and found them a ready source of food supply. The bird would approach and watch until one fluttered its wings, and then would seize it and swallow it, wings and all. I watched it for some time, and noticed that the yellow butterflies were the only ones eaten, although the others outnumbered them almost three to one. Whether the brighter color attracted the bird to these, or the others were distasteful, cannot be said with certainty, but I believe the former to be the case. A chipmunk, which also fed on these butterflies, caught and ate both species, carrying them to the shelter of a log, where it discarded the wings, leaving them in a large heap.—*The Condor.*

## SECRETARY-TREASURER'S REPORT.

NEW YORK STATE SCIENCE TEACHERS ASSOCIATION—TWENTIETH ANNUAL MEETING, DECEMBER 27, 28, 29, 1915.

*Central High School, Syracuse, N. Y.*

All meetings were well attended by the teachers who were interested in the various topics.

The Council meeting, scheduled for 12:15, December 28th, was omitted.

The regular business meeting was held as called for by the program, at 9:45 a. m., Wednesday, December 29th.

Meeting was called to order by the President, Mr. Bryan O. Burgin. The President called for the resolutions drawn up by the Committee on Resolutions, consisting of O. E. Hoffman, A. G. Clements and D. A. Cady. The resolutions were read by the Chairman, Mr. Hoffman, and are as follows:

"The New York Science Teachers' Association desires to express its appreciation and thanks to all who have contributed to its comfort, pleasure and profit during the meetings just held.

"Especially do we extend our thanks to the city of Syracuse for its welcome; to the press of the city for its interest and in the publication of the activities of the various meetings; to the Franklin Automobile Company for its courtesy in permitting us to inspect its plant; to the Central New York Science Club for arranging the trip through the automobile works; to the School Board for the use of rooms and equipment for our meetings; to the teachers of the high school who have given so unsparingly of their time and energy that we might have ample facilities for the carrying out of our program; and to those who have added to our enjoyment and profit by their addresses, exhibits, etc.

"Our thanks are due the officers of the Association for their untiring work in making this meeting a success. We have had the pleasure and profit, they have had the work and anxiety of planning and executing the work of the Association.

"Signed:
"O. E. HOFFMAN.
"A. G. CLEMENTS.
"D. A. CADY."

The motion was made and seconded that the resolutions as read be adopted by the Association. The motion was acted upon and passed unanimously.

The Committee on Nominations, of which Mr. Bailey of Geneseo was Chairman, offered the following slate for officers for the coming year:

President—E. F. Conway, Syracuse, N. Y.

Vice-President—R. G. Gibbs, Ithaca, N. Y.

Secretary-Treasurer—H. A. Carpenter, Rochester, N. Y.

Committee on Publication—E. R. Smith, Syracuse, N. Y.; C. B. Herschey, Buffalo, N. Y.

Council members, to hold office until 1919—John Merrill, Rochester, N. Y.; J. A. Randall, Brooklyn, N. Y.; H. H. VanCott, Schenectady, N. Y.

Auditors—O. C. Kenyon, Syracuse, N. Y.; M. C. Collister, Utica, N. Y.; H. H. VanCott, Schenectady, N. Y.

There were no additions to these nominations, and it was moved and seconded that the members selected for office, as suggested by the Committee on Nominations, be elected to office. The motion was put to vote and carried unanimously. The President then declared the members, as listed above, elected to their respective offices.

It was brought to the attention of the Association that the membership of the current year had fallen off considerably over that of the other years. The general topic of "Wherein Is the Association Failing of its Greatest Usefulness" was discussed by Dr. Hale, Mr. Cobb and others. The suggestion was made that additional efforts should be made for the purpose of increasing the interest and cooperation of all the science teachers of the state in the work of the New York State Science Teachers' Association. Facts were brought out, indicating that the Class A membership of the Association had not produced the results anticipated, and Mr. Bailey of Geneseo introduced the motion that the Executive Committee consider the question of continuing the Class A membership and other items relating to the increasing of the membership and activities of the Association. This motion was seconded and passed. The Secretary-Treasurer made a report of the meetings, withholding the balancing of the Treasurer's account until more of the members could be heard from. The report was acted upon and accepted.

Dated: December 29, 1915.

PHYSICS AND CHEMISTRY SECTION.

At the regular meeting of the Physics and Chemistry Section, held Wednesday morning, December 29, 1915, the Chairman, Dr. Clarence F. Hale, called for a report of the Committee on Nomination. The Committee on Nomination presented the name of W. A. Titsworth of Alfred University for Chairman of the Physics and Chemistry Section. It was moved, seconded and passed that the Secretary cast one ballot for Mr. Titsworth. The ballot was cast and Mr. Titsworth was duly declared elected.

BIOLOGY SECTION.

The business meeting of the Biology Section was called to order by the Chairman, Miss Ida L. Reveley, of Wells College, Aurora, N. Y. The Chairman called for a report of the Nominating Committee for the election of a Chairman for 1916. The nominating Committee reported the name of Miss Caroline A. Riker of Canandaigua Academy, Canandaigua, N. Y., for Chairman of the Biology Section. Motion was made and seconded that Miss Riker be the Chairman for the year 1916. Motion was put to vote and unanimously carried. Miss Riker was thereupon declared elected.

TREASURER'S REPORT TO APRIL 5, 1916.

*Receipts.*

| | |
|---|---|
| 6 Class A. 1915 dues | $ 12.00 |
| 62 Class A, 1916 dues | 124.00 |
| 1 Class A, 1916 dues | 1.50 |
| 12 Class B, 1915 dues | 12.00 |
| 51 Class B, 1916 dues | 51.00 |
| Exchange on checks | 1.20 |
| Refund on biology cards | .88 |
| Two months' subscription to Journal | .40 |
| | $202.98 |

*Expenses.*

| | |
|---|---|
| TO SCHOOL SCIENCE AND MATHEMATICS: | |
| Sixty-nine subscriptions at $1.50 | $103.50 |
| Two months' subscription to J. | .40 |
| Stamps (by Secretary) | 4.44 |
| Express on box of Secretary's books | .67 |

| | |
|---|---|
| Two money orders | .06 |
| Exchange on checks | .50 |
| Envelopes and printing | 2.50 |
| Stenographer | 2.45 |
| Two sets of index cards | .30 |
| Secretary's traveling expenses | 3.50 |
| President's expenses (traveling, postage, stationery, etc.) | 18.08 |
| Chairman, Biology Section (stationery, printing, postage) | 18.07 |
| Printing and stationery for 1916 | 9.85 |
| | $164.32 |
| Balance on hand, April 5, 1916 | 38.66 |
| | $202.98 |

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*Secretary-Treasurer.*

## THE OHIO POTTERY COMPANY'S LABORATORY PORCELAIN.

When it became a definite certainty that the foreign sources of supply for laboratory porcelain ware would be stopped for perhaps an indefinite period, and that chemical and other laboratory work in America would suffer serious inconvenience thereby, Mr. C. D. Fraunfelter, President of the Ohio Pottery Company, set to work on a long series of experiments on bodies and glazes for laboratory porcelain ware with the determination to produce an article that should be at least the equal of the famous standard ware, the Royal Berlin.

Many formulas for body and glaze were tried, and conditions of drying, glazing, burning and tempering were carefully studied. Thousands upon thousands of experimental pieces were made until finally success crowned his efforts, and a line of ware was produced which stood up under all of the tests given below.

The ceramic engineering problems were studied and solved by Mr. Fraunfelter. The chemical laboratory work and the testing of the ware, as well as many suggestions as to details of design and adaptability to laboratory practice, were contributed by Mr. Robert Carl Schroth, Jr., President of The Laboratory Supply Company.

Every trial run was subjected to the following tests, the results below being the properties exhibited by the series which was adopted for the market.

FIRST: *Heating and Cooling Test.* Each sample was taken at room temperature about 20° C.), plunged without preheating into a muffle furnace at 1700° F. After four minutes, it was removed by means of a pair of steel tongs, not previously heated, and tossed upon a steel plate in a draft with the following results:

| Kind of Ware. | No. of Trials. | No. Cracked or Crazed. |
|---|---|---|
| Ohio Pottery Company S | 8 | 0 |
| Royal Berlin | 4 | 1 |

SECOND: *Solubility in Thirty Per Cent Sulphuric Acid on Boiling for Six Hours.*

| Kind of Ware. | No. of Trials. | Average Per Cent Solubility. |
|---|---|---|
| Ohio Pottery Company S | 2 | .0016 |

THIRD: *Solubility in Twenty-five Per Cent Sodium Hydroxide on Boiling for Six Hours.*

| Kind of Ware. | No. of Trials. | Average % Solubility. | Condition. |
|---|---|---|---|
| Ohio Pottery Company S .. | 2 .. | 1.5 | ..Uniform and smooth effect on glaze. |
| Royal Berlin ..... | 2 .. | 1.8 | ..Uniform and smooth effect on glaze. |

FOURTH: *Effect of Ferric Oxide Ignition on Glaze.*

| Kind of Ware. | No. of Trials. | Average % Gain in Weight. | Condition. |
|---|---|---|---|
| Ohio Pottery Co. S .... | 2 .. | .001 | ..Glaze practically unaffected. No crucibles cracked. |
| Royal Berlin ..... | 2 .. | .006 | ..Glaze very badly discolored. One crucible cracked. |

FIFTH: Casseroles and evaporating dishes were run through limestone analysis and showed an average loss in weight of .001 per cent with glaze left smooth and clean.

SIXTH: Casseroles and evaporating dishes were run through iron and steel analysis and showed an average gain in weight of .002 per cent with glaze left smooth and clean.

SEVENTH: Photo micrographs were taken of different glazes and showed a practically homogeneous body free from pits and bubbles.

EIGHTH: Fractures were made and examined microscopically and showed perfectly vitreous, free from any granular structure.

## AN EXPERIMENT IN LIGHT.

Look at an open arc light through the stretched silk of an open umbrella, and a clear and distinct spectrum will be seen. For laboratory purposes, an ordinary silk handkerchief, tightly stretched, may be used for the same purpose.

## RAIL JOINTS AND BONDS.

*Modern Practice in the Construction and Maintenance of Rail Joints and Bonds in Electric Railways* is the title of Technologic Paper, No. 62, just issued by the Bureau of Standards, Department of Commerce. The paper is largely a compilation of information in the nature of data and opinions submitted by forty-two electric railway companies who answered inquiries sent out by the Bureau.

Analysis of the data shows that soldered bonds have been demonstrated to be unsuccessful and are now practically obsolete, while all other types of standard bonds are capable of giving good results, but only when carefully installed.

Loose rail joints are shown to be the most prevalent cause of bond failures and as a result there appears to be a marked tendency toward the adoption of improved methods and materials in their construction. The adoption of various types of welded joints to take the place of the common bolted joint appears to be in progress in most of the larger cities. The whole problem of track bonding is shown to be in a state of evolution, owing to new inventions and recent improvements in methods of construction, and, as a result, complete standardization of these practices cannot be expected for some time to come.

The character of track bonding is determined largely by the necessity for good operation and the prevention of stray currents which have a corrosive action on underground pipes. Economic considerations are shown to be of secondary importance.

Copies of the publication will be sent free to those interested who apply to the Bureau of Standards, Washington, D. C.

## BOOKS RECEIVED.

Community Arithmetic, by Brenelle Hunt, Normal School, Bridgewater, Mass. Pages viii+277. 14x19 cm. Cloth. 1916. American Book Company, Chicago.

Geology, Physical and Historical, by Hardman F. Cleland, Williams College. 714 pages. 15x22.5 cm. Cloth. 1916. American Book Company, Chicago.

Textbook of Anatomy and Physiology for Training Schools, by Elizabeth R. Bundy, Woman's Hospital, Philadelphia. Pages xiii+410. 16x22.5 cm. Cloth. 1916. 1.75 net. P. Blakiston's Son & Company, Philadelphia.

Field Crop Production, by George Livingston, Ohio State University. Pages xix+424. 13x19.5 cm. Cloth. 1916. $1.40. The Macmillan Company, New York.

The Science of Musical Sounds, by Dayton C. Miller, Kay School of Applied Science, Dayton, Ohio. Pages xxiv—286. 14.5x22 cm. Cloth. 1916. The Macmillan Co., New York City.

The Panama Canal, by Frederic J. Haskin. Pages x—386. Cloth. 1913. Doubleday, Page & Co., New York City.

Diamonds—A Study of the Factors That Govern Their Value, by Frank B. Wade, Shortridge High School, Indianapolis. Pages viii—150. 13x19 cm. Cloth. 1916. G. W. Putnam's Sons, New York City.

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## BOOK REVIEWS.

*Geology—Physical and Historical, by Herdman F. Cleland, Williams College.* 718 pages. 15x22.5 cm. Cloth. 1916. American Book Company, Chicago.

Of the many books which have recently been written on this general topic, this is unquestionably one of the best. It is without doubt a most remarkable book from every point of view. It not only contains a vast fund of information, both for the geologist and earth science teacher, but the matter is written in such an extremely interesting style that anyone having an inclination toward science cannot help but be interested by it. It is profusely illustrated, having 588 cuts and figures, a good many of which were prepared especially for this work. The book is divided into two parts, the first being devoted to physical geology, and the second to historical geology. In the first part, there are twelve chapters, which cover almost every phase of the subject. In part two there are ten chapters which discuss the subject matter pertaining to the history of geology. It is a book which every teacher of earth science and geology should possess. It ought to be in every library of the country. The major paragraphs begin with bold-faced type. At the end of each chapter, there is given a list of reference books, together with topographical maps, which will assist one in the study of the particular matter discussed. There is a very complete index, consisting of twenty-four pages. Mechanically, the book is well made. One can do nothing but praise the book from all points of view.

C. H. S.

*Electrical Measurements and Testing—Direct and Alternating Currents, by Chester L. Dawes, Harvard University.* 88 pages. 20x26.5 cm. Paper. 1916. 75 cents net. John Wiley & Sons, New York City.

This is another one of those interesting and valuable laboratory manuals issued by this house and edited by Prof. J. M. Jameson of Girard College. The manual contains thirty-nine splendid electrical experiments, which have been selected not only for practical application, but from an educa-

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tional point of view. The experiments are not for secondary school work except in the more advanced high schools, but are to be used mainly in colleges and technical schools. All instructors in electricity in technical schools should possess themselves of this most excellent manual.

C. H. S.

*Lessons in Elementary Physiology, by Thomas H. Huxley, LL. D., F. R. S.* Enlarged and revised edition. Pages xxiv+604, with 185 figures in the text. 12x19 cm. Cloth. 1915. The Macmillan Company.

It would be presumptuous for the reviewer to attempt the review and criticism of this work. It has been long in use and is well known to students of science. The present edition has been issued in an attempt "to 'restore' the work of these men (Huxley and Foster) from the dilapidations made by two decades of scientific progress."

This work of revision has been done by Joseph Barcroft, King's College, Cambridge. He says, "I have faithfully left untouched any portion of the fabric in which there was not an actual flaw." Students and teachers of physiology will be glad to have such a standard work as this was brought up to date with the progress of scientific knowledge. W. W.

*The Development of the Human Body, a Manual of Human Embryology, by J. Playfair McMurrick, Professor of Anatomy in the University of Toronto.* Fifth edition, revised and enlarged, with 287 illustrations in

the text. Pp. x+493. 13x20 cm. Cloth. $2.50. P. Blakiston's Sons & Company, Philadelphia.

This is a revised edition of a book well known to students of biology. The author has attempted "to incorporate the results of all important recent contributions upon the topics" included in the book. The entire book has been "thoroughly revised."

The book is beautifully printed in large, clear type and is generously illustrated—an important feature of such a textbook. Teachers desiring an accurate statement of our present knowledge of the development of the human body will do well to add this volume to their library. W. W.

*Solid Geometry, by William Betz, East High School, Rochester, N. Y., and Harrison E. Webb, Central Commercial and Manual Training High School, Newark, N. J.* Pages xxii+177. 13x19 cm. 1916. 75 cents. Ginn & Company, Boston.

In their endeavor to harmonize the modern demands with the best traditions of the subject, the authors have been very successful. They have presented the subject stripped of enough of its old formalism and enriched with interesting and practical exercises and problems to make it of more real value in the life of the pupils.

A brief introductory chapter gets the pupils to work on actual solids at once, and helps to make concrete the formal work on lines and planes that seems to many such an inauspicious approach to the subject. The rearrangement and elimination of topics makes it possible to give more time to exercises and applications, of which there are good lists, well distributed. The numerous illustrations, discussions, and historical notes will serve to arouse the interest of the pupils. The authors and publishers may well be congratulated on the scholarly qualities and excellent workmanship of this book. H. E. C.

*Invertebrate Zoology, a Guide to the Dissection and Comparative Study of Invertebrate Animals, by Henry Sherring Pratt, Ph. D., Professor of Biology at Haverford College.* Revised edition. Pp. xii+228. 14x21 cm. 1915. Published by Ginn and Company.

This guide is well known to all zoologists and needs no statement by the reviewer as to its purpose and method, nor as to its excellence. The present volume has been "revised" by the addition of several dissections not included in former editions. These are the house fly, a spider, the oyster, a sea cucumber, Gonionemus, and a sea anemone. The table of classification has also been rewritten.

The book is intended for college students and is a standard guide to the dissection of invertebrate animals. W. W.

## GOVERNMENT HELPS IN PHYSIOGRAPHY.

The public in general and many physiography teachers in particular probably do not appreciate the fact that our national government is frequently publishing pamphlets and booklets describing our national parks and other features of the country. If read and studied by a larger proportion of our physiography teachers, these would enable them to present to their pupils in a much more intelligent way, matters concerning the country in which we live. One of the most helpful booklets printed by the government is that on *Glimpses of Our National Parks,* prepared by Robert S. Yard. It contains thirty-eight pages and gives a brief historical and descriptive outline of the ten of eleven national parks of our country. It is written in such a fascinating way that pupils of the eighth and ninth grades cannot only understand the matter, but will be intensely interested in reading it. Then, too, teachers will get instruction from the book which will help them to get busy on topics suggested therein. It may be secured by anyone from the Department of the Interior, for five cents.

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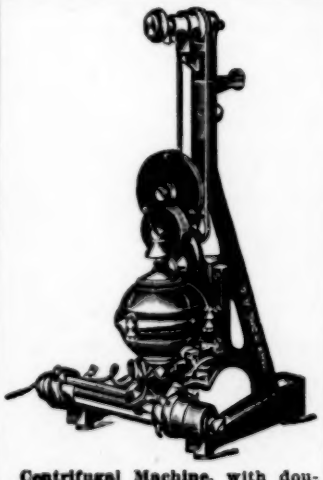

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## DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become a year old.

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